COSEWIC
Assessment and Status Report

on the

Wolverine
Gulo gulo

in Canada

SPECIAL CONCERN
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC. 2003. COSEWIC assessment and update status report on the wolverine *Gulo gulo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 41 pp.

Dauphiné, T.C. 1989. Update COSEWIC status report on the wolverine *Gulo gulo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 31 pp.

Kelsall, J.P. 1982. COSEWIC status report on the wolverine *Gulo gulou* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 50 pp.

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COSEWIC
Assessment Summary

Assessment Summary – May 2014

Common name
Wolverine

Scientific name
Gulo gulo

Status
Special Concern

Reason for designation
This wide-ranging carnivore has an estimated Canadian population likely exceeding 10,000 mature individuals. Although population increases appear to be occurring in portions of the Northwest Territories, Nunavut, Manitoba and Ontario, declines have been reported in the southern part of the range, e.g. in British Columbia, and populations in a large part of the range (Quebec and Labrador) have not recovered. The species may be extirpated from Vancouver Island. Population estimates are very limited, and trends are not known. Most data are limited to harvest records, and harvest levels may be under-reported because many pelts used domestically are not included in official statistics. There is no evidence, however, of a decline in harvest over the last 3 generations. This species' habitat is increasingly fragmented by industrial activity, especially in the southern part of its range, and increased motorized access increases harvest pressure. Climate change is likely impacting animals in the southern part of the range, and this impact is expected to increase northward. The species has a low reproductive rate, is sensitive to human disturbance, and requires vast secure areas to maintain viable populations.

Occurrence
Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland and Labrador

Status history
The species was considered a single unit and designated Special Concern in April 1982. Split into two populations in April 1989 (Western and Eastern populations). The original designation was de-activated. In May 2014, the Eastern and Western populations were considered as a single unit across the Canadian range and was designated Special Concern.

COSEWIC
Executive Summary

Wolverine
Gulo gulo

Wildlife Species Description and Significance

Wolverines are a stocky, medium-sized carnivore and the largest terrestrial member of the weasel family. They have long, glossy coarse fur, which varies from brown to black, often with a pale facial mask and stripes running laterally from the shoulders, crossing just above the tail. The skull structure is robust, allowing it to crush and consume bones and frozen carcasses. Adult males weigh 13 to 18 kg and adult females weigh 7.5 to 12.5 kg.

A single subspecies, *Gulo gulo luscus*, ranges across most of Canada. Further studies are required to determine if the Vancouver Island population is a separate subspecies, *G. gulo vancouverensis*. A single designatable unit is recognized for the Canadian population.

Wolverines may indicate ecosystem health, given their dependence on extensive connected ecosystems that support ungulates and large carnivores which create opportunities for scavenging. They are a valuable furbearer in the fur trade, and many furs that do not enter the fur trade are used locally, especially in the Arctic, where its frost-resistant fur is used for parka trim.

Distribution

Wolverines are found across northern Eurasia and North America. In Canada, they are found in northern and western forested areas, in alpine tundra of the western mountains, and in arctic tundra. It is not known whether Wolverines currently occupy Vancouver Island, Québec, or Labrador. Range reductions began in the 19th century, and subpopulations were extirpated from New Brunswick, southern Ontario, and from the aspen parkland of Manitoba, Saskatchewan and Alberta.

Habitat

A wide variety of forested and tundra vegetation associations are used by Wolverines. Habitats must have an adequate year-round supply of food, mainly consisting of smaller prey such as rodents and Snowshoe Hares, and the carcasses of large ungulates, like Moose, Caribou, and Muskox. Females den under snow-covered rocks, logs or within snow tunnels. Wolverines reproduce in areas where snow cover persists at least into April.

Biology

Most females breed after they are 2 or 3 years of age and produce on average 2 kits per litter. Wolverine home ranges are 50-400 km^2 for females (smallest during denning periods) and 230-1580 km^2 for males. Home ranges may overlap within and between sexes but home ranges of reproductive females do not overlap. Home range size in the eastern range is unknown. Wolverine densities are low and range from about 5 to 10/1,000 km^2. Wolverines are scavengers and predators, often caching food for future use. Wolverines face mortality from predation and starvation. Anthropogenic sources of mortality include trapping, hunting, and road kill.

Population Sizes and Trends

Confidence regarding population size and trend is debated because most population data are derived from harvest records and the proportion of unreported harvest varies across their range. The Canadian population size is unknown but likely > 10,000 adults. Wolverine have been extirpated (or likely extirpated) in much of southern and eastern Canada. Wolverine observations continue to be reported in the range of the eastern sub-population (Québec and Labrador), but no observation has been verified since 1978. The last verified record on Vancouver Island was in 1991 and it is likely that they have been extirpated. There is concern that decline may be occurring in BC and parts of Alberta where Southern and Central Mountain Caribou, their primary prey, continue to decline and habitats are fragmented. Field studies since 2003 suggest Wolverines are more abundant in parts of the Northwest Territories (NWT) and Nunavut than previously thought. The sub-population in the NWT barren ground region may be decreasing while recent records in western Arctic islands suggest population increase, although it is unknown if these are resident or transient animals. Population trends are unknown, but based on numerous sources such as field studies, ATK, and trapper surveys, they are believed to have been stable over parts of the northern range for the last 3 generations (22.5 years). Wolverines in northern Manitoba and Ontario may be increasing; aerial surveys in northern Ontario have shown an eastward range reoccupation towards James Bay and Québec.

Threats and Limiting Factors

The variability in trap effort, the uncertainty on actual harvest levels in some jurisdictions, and increased access and efficiency of hunting using snowmobiles raises concerns over potential overharvest and the ability to document population size and trends. Transportation corridors, forestry, hydroelectric developments, oil and gas and mineral exploration and development increase access for harvest and contribute to permanent, temporary or functional habitat losses (sensitivity to disturbance), which may destabilize populations.

The decline in Caribou as a source of scavenged meat, particularly in Québec and Labrador where few Wolverines may persist, may limit population recovery. Other factors that may limit populations include harvest, disturbance of denning areas, threats to habitats, and population fluctuations in Wolves and other carnivores that provide scavenging opportunities. The Threats Calculator calculated an overall threat impact of medium.

Protection, Status, and Ranks

This species was assessed as Endangered by COSEWIC in 2003 and is listed on Schedule 1 of the *Species at Risk Act* (SARA). The Western Population (labelled western sub-population in this report) was assessed as Special Concern by COSEWIC in 2003, but was not listed under SARA due to concerns expressed by the Nunavut Wildlife Management Board. Provincial designations are Endangered in Labrador, and Threatened in Ontario and Québec (note: 'Threatened' is equivalent to Endangered in Québec). Remaining provincial designations range from no ranking to Sensitive or Special Concern. NatureServe (2013) rankings are Critically Imperilled (S1) in Québec and Newfoundland and Labrador, and Imperilled (S2) in Ontario. The Vancouver Island population is Imperilled. Wolverines are protected from non-Aboriginal harvest in Québec, Newfoundland and Labrador, and Ontario, although unreported harvest may be occurring. Aboriginal harvest would be in the northern part of the range (*i.e.,* James Bay and Northern Québec Agreement area). Wolverines are trapped and hunted in most other areas of their confirmed range.

Habitat Protection and Ownership

Numerous protected areas exist within the Wolverine's range but refugia larger than 20,000 km^2 may be required to maintain a Wolverine population. Many northern national, provincial and territorial parks allow trapping. In southern parks, population recovery may be impacted by road developments that can act as barriers to movements, and activities such as skiing and snowmobiling that may disturb denning females.

TECHNICAL SUMMARY

Gulo gulo
Wolverine

Carcajou

Range of occurrence in Canada: Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, Newfoundland and Labrador

Demographic Information

Generation time (estimated average age of breeding females in the population)	7.5 yrs
Is there an observed continuing decline in number of mature individuals? *Last verified record in eastern sub-population was in 1978, and Vancouver Island in 1991.*	No; declines in south and east have occurred but some sub-populations may be increasing in north
Estimated percent of continuing decline in total number of mature individuals within 2 generations (15 years). *Harvest indices in much of northern range suggest stable populations but value of trap data uncertain.*	Unknown, but possibly increasing in northern, and likely decreasing in southern range
Observed percent reduction in total number of mature individuals over the last 3 generations (22.5 years)	0
Projected percent reduction in total number of mature individuals over the next 3 generations (22.5 years).	Unknown
Observed percent increase in total number of mature individuals over any 3 generations period, over a time period including both the past and the future. *There are reports of possible population increases in Nunavut and NWT.*	Unknown
Are the causes of the decline clearly reversible and understood and ceased? *Declines in Vancouver Island and eastern sub-population are not understood and have not reversed.*	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence. *If unverified observations in eastern sub-population are used, EO is an additional 0.88 million km².*	>10 million km²
Index of area of occupancy (IAO).	>4,000 km²
Is the population severely fragmented?	No
Number of locations*	Many
Is there an observed continuing decline in extent of occurrence?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an observed continuing decline in quality of habitat?	Yes, in some areas, notably in southern range, and areas of industrial development
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Western sub-population (ON, MB, NU, NWT, YK, SK, AB, BC)	Unknown, likely >10,000
Eastern sub-population (LAB, QU)	Unknown, likely near 0
Total	Unknown, likely >10,000 mature individuals

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not conducted, but likely a high probability in eastern sub-population range

Threats (actual or imminent, to populations or habitats)

Potential overharvest associated with unknown harvest levels and facilitated by extensive access associated with snowmobile use. Habitat loss (permanent, temporary and/or functional) and fragmentation due to forestry, agriculture, oil and gas development, hydroelectric reservoirs, and roads. In southern range, functional habitat loss due to disturbance caused by recreational activities, such as ATVs, snowmobiles, hiking and skiing during the denning period, along roads and trails. Declining ungulate (esp. Caribou) populations represent loss of important source of food. Climate change concerns in southern range.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? *Secure in Alaska; Alaskan population is adjacent to northern BC, YT. Sensitive or At Risk in the conterminous U.S. states and a candidate species for federal listing as Threatened; southern population is adjacent to BC and Alberta.*	Secure in Alaska; potentially Threatened in US states south of Canada
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely? *Rescue possible from Alaska but unlikely from conterminous US.*	Yes/No

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Data-Sensitive Species

Is this a data-sensitive species?	No

COSEWIC Status History

The species was considered a single unit and designated Special Concern in April 1982. Split into two populations in April 1989 (Western and Eastern populations). The original designation was de-activated. In May 2014, the Eastern and Western populations were considered as a single unit across the Canadian range and was designated Special Concern.

Status and Reasons for Designation:

Status:	**Alpha-numeric code**:
Special Concern	Not applicable

Reasons for designation:

This wide-ranging carnivore has an estimated Canadian population likely exceeding 10,000 mature individuals. Although population increases appear to be occurring in portions of the Northwest Territories, Nunavut, Manitoba and Ontario, declines have been reported in the southern part of the range, e.g. in British Columbia, and populations in a large part of the range (Quebec and Labrador) have not recovered. The species may be extirpated from Vancouver Island. Population estimates are very limited, and trends are not known. Most data are limited to harvest records, and harvest levels may be under-reported because many pelts used domestically are not included in official statistics. There is no evidence, however, of a decline in harvest over the last 3 generations. This species' habitat is increasingly fragmented by industrial activity, especially in the southern part of its range, and increased motorized access increases harvest pressure. Climate change is likely impacting animals in the southern part of the range, and this impact is expected to increase northward. The species has a low reproductive rate, is sensitive to human disturbance, and requires vast secure areas to maintain viable populations.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Unknown. Evidence for declines in some parts of its range, but may be increasing in others.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not Applicable. EO and IAO exceed thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not Applicable. Population size likely exceeds 10,000 mature individuals.
Criterion D (Very Small or Restricted Population): Not Applicable. Population exceeds 1,000 mature individuals.
Criterion E (Quantitative Analysis): Not Applicable. Analysis has not been conducted for the Canadian population.

PREFACE

Notice: Some of the information used or referenced in this document is Government of the Northwest Territories Copyright, compiled on behalf of the Northwest Territories Species at Risk Committee under a contract with the Department of Environment and Natural Resources (Northwest Territories Species at Risk Committee (NWT SARC) 2013).

The original April 1982 COSEWIC status designation for Wolverines was Rare, which was synonymous with Special Concern prior to 1990 (Kelsall 1981). In April 1989, two populations were delineated, the Eastern Population of Québec and Labrador, and the Western Population of Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories (NWT), and Nunavut (Dauphiné 1989). The justification for the separation was based on the very low, or extirpated, population found in Québec and Labrador, rather than the criteria of discreteness or significance used in present COSEWIC guidelines. Dauphiné (1989) suggested that the Eastern Population should be classified as Extirpated.

The COSEWIC status designations were Vulnerable for the Western Population (again, synonymous with Special Concern between 1990 and 1999), and Endangered for the Eastern Population. The status designations were confirmed in May 2003 for the Western Population (Special Concern) and Eastern Population (Endangered) (COSEWIC 2003). The Eastern Population is listed on Schedule 1 of the *Species at Risk Act* (SARA) as Endangered, but the Western Population was not added to the SARA list in order to further consult with the Nunavut Wildlife Management Board (NWMB) and the Nunavut government. Issues for the NWMB centred on the lack of ATK, inadequate consultation, issues with land claims agreement, and evidence of increasing population in Nunavut (Crystal pers. comm. 2014). The consultation process occurred in 2005; however, the Minister of Environment did not issue a recommendation.

A substantial number of Wolverine research projects underway at the time of writing the previous update status report on Wolverine (COSEWIC 2003) have since been completed. There have been publications on the effect of global warming on the Wolverines' habitat requirement of late spring snow cover, genetic structuring at the southwest and eastern peripheries of the Wolverine's range, distribution and abundance of Wolverine at the eastern edge of the species' range in Ontario, and population density estimates in the southern Arctic ecozone in the NWT and Nunavut, and in montane and foothill habitats in western Alberta.

Ecozones and ecoregions discussed in this report are based on the scheme presented by the Ecological Stratification Working Group (1995). The 8 COSEWIC 'National Ecological Areas' are amalgamations of the 15 terrestrial ecozones.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2014)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada

Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Wolverine

Gulo gulo

in Canada

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Figure 3. North American distribution of Wolverine. Adapted from COSEWIC (2003), Magoun *et al.* (2004), Ray (2004, 2012), Aubry *et al.* (2007), Thibault unpubl. data (2013). Map produced by Bonnie Fournier, NWT. Increased presence refers to observations of Wolverine on various islands, but it is not known if these are established or vagrant individuals. 12

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Family: Mustelidae

Latin Name: *Gulo gulo*

English: Wolverine

French: Carcajou

Aboriginal: ʔaȼp̓u (Ktunaxa), cišps (Salish), Kalvik / Qalviit (Inuktitut), Qavviit (Inuvialuit), kihkwahâkew (Plains Cree), Kuakuatsheu / kuekuatsheu (Innu), mámex-áy-shen (she shashishalhem), naghay (southern Tutchone), nàhtyä' (Hän), Nehttryooh/Nehtryuh (Gwich'in – Gwich'in Settlement Area), Nehttryuh / nèhtrùh (Gwich'in – North Yukon), Nogha / Nághai (Dene), Noolh'utughih (Dakelh – Southern Carrier), noosik' (Gitsenimx and Nisga'a), nóoskw (Tlingit), Noostel (Dakelh – Nadleh Whut'en), Noostel (Dakelh – Nak'azdli Dakelh), nòòwa (Kwadacha Tsek'ene) , nowa (Tse'K'hene), nuštil (Tsilhqot'in (Xeni Gwet'in)), nowe (Tsaa? Dene (Beaver People)), nustël (Wet'suwet'en), ogwiingwa'aage+g (Ojibwe), Piinotoyi (Blackfoot), Qavvik (Inuktitut – Inuit), quts'ik (Nuxalk), Qwílqwn (Secwepemc – Northern Státimcets), qwílqen ((Ĺiĺwat), shxwématsel (Upriver Halkomelem)).

Wolverines (*Gulo gulo*; Linnaeus 1758) in North America were formerly known as *Gulo luscus* until they were shown to be conspecific with Wolverine in Europe and Siberia (Kurtén and Rausch 1959). Up to four subspecies had been recognized in North America (Hall 1981), two of which occur in Canada; *G. g. luscus*, found across Canada, Alaska and the northwestern United States, and *G. g. vancouverensis*, found on Vancouver Island (see **Designatable Units** section). Taxonomists presently recognize only either a single subspecies (*G. g. luscus* in North America), or recognize *G. gulo* as a single Holarctic taxon (reviewed in Tomasik and Cook 2005).

Morphological Description

Wolverines are a medium-sized (*i.e.* 1-m long) carnivore and the largest terrestrial member of the weasel family in North America, appearing more like a small bear than a weasel (Figure 1; Inuvik Community Corporation (ICC) *et al.* 2006). It has long, glossy coarse fur, which varies from brown to black, often with a pale facial mask and yellowish or tan stripes running laterally from the shoulders, crossing just above the tail (Gwich'in Renewable Resources Board (GRRB) 2001; Cardinal 2004). Most individuals have a pale white or orange patch on the neck and chest. It has a large head, broad forehead, short stout neck, short stocky legs, and a heavy musculature. The feet are large, ears short and the tail is long and bushy. The skull structure is robust, allowing it to crush bones and consume frozen carcasses. Wolverines are sexually dimorphic with adult females ranging in size from 7.5 to 12.5 kg and males weighing 13 to 18 kg (Magoun

1985; Banci 1994; Copeland 1996; Mulders 2000; GRRB 2001; Lofroth 2001; Cardinal 2004; Golden unpubl. data 2013).

Figure 1. Illustration of the Wolverine. (Credit: Lee Mennell).

Population Spatial Structure and Variability

The amount of population genetic structuring varies by scale. At the continental scale, Wolverine have limited structuring in the core range but increasing structure at the southwestern and eastern range peripheries (Wilson *et al.* 2000; Kyle and Strobeck 2001; 2002; Chappell *et al.* 2004; Zigouris *et al.* 2012). These studies are based on nuclear DNA markers. The largely panmictic condition in the core is believed to be due to long-range dispersal behaviour by males (see **Dispersal and Migration** section). The increased structure at the peripheries is believed to be due to isolation, and possibly separate origins from multiple glacial refugia (see **Designatable Units** section). At the local scale, increased genetic structuring has been recorded using mitochondrial DNA (mtDNA) analyses (Tomasik and Cook 2005; Cegelski *et al.* 2006; Schwartz *et al.* 2007; Zigouris *et al.* 2012; 2013). This local structuring is believed to be due to a strong preference by females to remain near their natal territories (Tomasik and Cook 2005; Cegelski *et al.* 2006; Schwartz *et al.* 2007; Zigouris *et al.* 2012).

Designatable Units

A single subspecies is presently recognized for Wolverine in North America (Tomasik and Cook 2005). Earlier classifications had recognized a separate subspecies on Vancouver Island but its status is debated; the 1935 proposal was based on a sample of only two skulls (Cowan and Guiguet 1960) and Banci (1982) concludes there is little evidence for classifying the Vancouver Island population as a distinct subspecies, based on morphometrics. Adequate samples are not available for significant genetic analyses; however, the one sample that had been processed for the control region of mtDNA revealed a genetic type found throughout the contemporary range of wolverines (Zigouris pers. comm. 2013), suggesting a lack of uniqueness from mainland Wolverine. Until further work is done, this report does not recognize the Vancouver Island population as a designatable unit (DU). According to knowledge holders in the ATK report on Wolverine (Cardinal 2004), ATK across most of the range does not differentiate Wolverine into more than one type. However, there is ATK from the Kivalliq region of Nunavut noting two types; one variety that is larger and lighter-coloured ("greater wolverine"), and another variety that is smaller and darker ("lesser wolverine"), and more common towards Yellowknife. Some participants stated that the greater wolverine variety may just be older individuals and the lesser wolverines are younger ones. However, one knowledge holder in Arviat stated that the teeth and claws of some of the lesser variety that he had caught indicated that they were older individuals, suggesting two types. Cardinal (2004) notes that without more research, it is difficult to discern whether there are actually two different varieties, or whether the differences can be attributed to another factor such as age or sex.

COSEWIC had produced a Status Report (COSEWIC 2003) with two populations ('Eastern'; Québec and Labrador, and 'Western'; Ontario westward and northward), but the reasons for separating those populations would not be relevant to present guidelines on DUs. The initial recognition by COSEWIC of the Eastern Population was based on its low population size and isolation from the Western population (Dauphiné 1989). The existing criteria for DU are discreteness and significance (Appendix F5 Operation and Procedures Manual), and the Eastern population, as presently delineated by population size, would not be recognized by COSEWIC.

Evidence for Discreteness

COSEWIC identifies discreteness, in part, by evidence of inherited traits (*e.g.*, morphology, life history, behaviour) and/or neutral genetic markers (*e.g.*, allozymes, DNA microsatellites, DNA restriction fragment length polymorphisms (RFLPs), DNA sequences). Using mtDNA analyses on 183 specimens and nuclear DNA on 246 specimens from Ontario, Manitoba, Saskatchewan, Nunavut and NWT, Zigouris *et al.* 2012 recognized two main sub-populations in Canada. Wolverines from NWT, Nunavut and Saskatchewan are part of a large panmictic core population. Wolverines in the Manitoba/Ontario region were unique; the genetic composition of Wolverine (n = 40 mtDNA; n = 82 nuclear DNA) from the Manitoba/Ontario region was different from the western samples, potentially reflective of long-standing differences between regions

(Zigouris *et al.* 2012). The Q values were relatively weak, however, indicating a mixing of haplotypes between the Manitoba/Ontario and remaining samples. Also, these analyses lacked samples from Quebec/Labrador and the southwestern US, which could influence the relative discreteness of the Manitoba/Ontario samples (Zigouris *et al.* 2012).

Additional mtDNA-based work on a larger, species-wide sample (n = 230 Eurasia; 148 Alaska; 188 contiguous US) identified 4 genetic clusters in Canada (Zigouris *et al.* 2013). The clusters, based mainly on haplotype frequencies, were in: 1) western Canada (BC, YK, AB, n = 161); 2) northern Canada (northern SK, NU, NWT, n = 151); 3) eastern Canada (ON, QC, Labrador, n = 67); and 4) Manitoba (n = 30). The Manitoba samples were distinct from all others. This expanded dataset provides more context for the relative amount of mtDNA control region genetic structure between ON, MB, NU, and NWT, where significant genetic structure was observed among other northern and western populations found to be nearly panmictic with nuclear DNA microsatellites.

Evidence for Significance

An additional criterion for DU is significance, which is represented as: 1) a gap in the population's range, or (2) the need for genetic differences reflecting deep divergence. The Eastern population is on the edge of the species' range and its removal as a DU would not be a gap within the population. Deep divergence implies genetic differences are the result of local evolutionary selection, typically because of long periods of isolation from other populations, often as a result of glacial refugia. The difficulty in interpreting present haplotype distribution is whether it is the product of a single refugia (which would not support deep divergence) with subsequent population bottlenecks and genetic drift, or multiple refugia (which would support deep divergence, and multiple DUs). The issue is compounded further by relative lack of genetic samples from the eastern population. Finally, uncertainty exists because deep phylogentic breaks cannot be assessed using only a small portion of the control region of the mitochondrial genome that is not under strong natural selection (see Zigouris *et al.* 2012; 2013; McKelvey *et al.* 2013). Data from other mitochondrial genes or mitogenomes and nuclear DNA analyses may bring additional clarity; however, these analyses will continue to be limited by sample sizes of this low-density and highly vagile creature in eastern regions.

The cause of the genetic structuring between regions is unknown. One model posits that Wolverine were isolated in multiple glacial refugia followed by long-range dispersal events, which allowed re-population of vacant areas and eventual contact between different genotypes (Zigouris *et al.* 2012; McKelvey *et al.* 2013). Unique haplotypes found in peripheral populations led McKelvey *et al.* (2013) to conclude that a population in the United States (as far south as California) persisted in refugia south of the last glacial sheet (approx. 18000 YBP) and then were extirpated in the 1800s. The unique 'California' haplotype is closely associated with genotype from Eurasia, and the authors consider this as evidence of common ancestry associated with early invasion by Wolverine into North America. Based on haplotypes common to Wolverine found today in western Canada and the northwestern US, McKelvey concludes Wolverine then

restocked the northwestern US from Canada in the early 1900s. The different genotype reflects their origins as a separate, isolated population that moved south after persisting in refugia in Alaska. In this model, the discreteness of Wolverine haplotype in the Manitoba/Ontario region may represent the boundary where two genotypes from separate glacial refugia presently meet.

A second model posits that there was a single refugium and any subsequent genetic differences are due to local breeding dynamics (Zigouris *et al.* 2013). In this model, the discrete haplotype distribution in Manitoba/Ontario is an artifact of a severely reduced population in the east and a concurrent loss of haplotypes. It is possible that some genetic types were eliminated by genetic drift and others increased in frequency relative to the north and west; the unique haplotypes could be remnants in a biased sample relative to other regions that retain larger, more genetically diverse populations (Kyle pers. comm. 2014). Female philopatry would also result in creation of some degree of local genotype.

It is unlikely that the discrete genotype in the Manitoba/Ontario region is an adaptation to local environment or habitats. Zigouris *et al.* (2012) notes that the Manitoba/Ontario region is dominated by extensive wetlands of the Hudson Plains Ecozone, whereas the core western population inhabits Taiga and Boreal Shield Ecozones (CFS 2013). There is some evidence of biogeographic influences on Wolverine genotype; differences in spring snow cover along dispersal routes were shown to explain genetic distance in Wolverines in the US Rocky Mountains (Schwartz *et al.* 2009). However, Wolverines are highly vagile and are found in many habitat types, suggesting local conditions would not be reflected in a species with extensive movement by males (see **Dispersal and Migration** section)

Four hypotheses explaining genotype distribution of Wolverines in North America were tested by Zigouris *et al.* (2013). None of the models were strongly supported but the strongest was the model wherein Wolverines arrived in North America in a single event from Siberia, then colonized the continent from west to east. The pattern would be consistent with that of a single refugium and subsequent expansion during glacial retreat. Also, the pattern of haplotype distribution in North America (Figure 2) is more likely the result of a single refugium model than a multiple refugia model; in a multiple refugia model, haplotypes would be clustered in several groups, rather than being distributed in a star radiation pattern typical of rapid expansion from a single source across most of the range, as indicated (Zigouris *et al.* 2013).

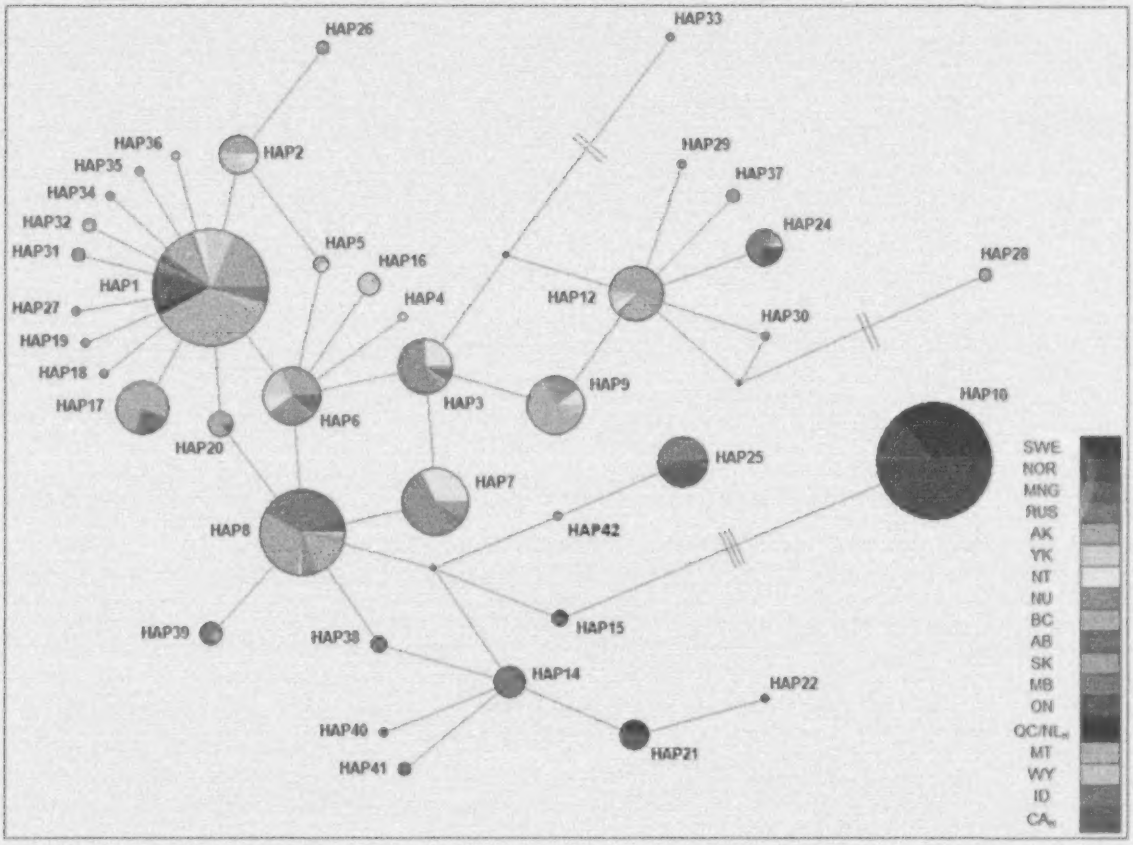

Figure 2. Median-joining network of mtDNA control region haplotypes of samples originating from Eurasia (Sweden, Norway, Mongolia, Russia) and North America (see Zigouris *et al*. 2013 for jurisdictions used in key). Each branch represents one mutation step. (Source: Zigouris *et al*. 2013 [doi:10.1371/journal.pone.0083837.g004], used with permission).

In summary, although the two populations in COSEWIC (2003) did not include genetic information, recent genetic analyses have established the presence of discrete genetic units. Essentially, there is a small fragment of mtDNA that evolves quickly and indicates female philopatry across the range, some evidence of two genetic groups, and slightly more differentiation of Manitoba/Ontario from the north and west. NuclearDNA shows near panmixia, with the exception of Manitoba/Ontario. The cause of the discrete genotype in the Manitoba/Ontario region is unknown.

The criteria of significance for a designatable unit has not been met. The Q values for discreteness are relatively weak. The discrete haplotypes in the Manitoba/Ontario region are more likely the product of a reduced population than an adaptation to local conditions. The mtDNA data largely represent the maternal genetic structure of Wolverines where clear breaks in frequency distributions of common haplotypes are found throughout their range, and, given the observation of near panmixia using neutral nuclear microsatellite loci for most of the range, the mtDNA results most likely are

reflective of male-biased dispersal and female philopatry and not locally adapted subpopulations. Evidence to date suggests a single refugium model, and thus a lack of deep divergence. Also, a similar genotype distribution is apparent in other large Holarctic carnivores (*i.e.,* Grizzly Bear, Polar Bear). Similar to Wolverine, these species possess high vagility in males and female philopatry and are considered a single DU across their Canadian range (COSEWIC 2008, 2012a). A single DU for Wolverine is recognized in this report.

Information is presented for the Canadian range, or when necessary, separated into western and eastern sub-populations. The eastern sub-population (Québec and Labrador) is isolated from the western sub-population and subject to different threats.

Special Significance

Wolverines are potential indicators of ecological integrity and disturbance due to biological characteristics and their dependence on large, connected and intact ecosystems (Carroll *et al.* 2001; GRRB 2001; Cluff and Paquet 2003; Cardinal 2004). Wolverines are viewed as one of several species of carnivores, which should be used in multi-species conservation planning in the Rocky Mountain region (Carroll *et al.* 2001) and northern Canada (Cluff and Paquet 2003). In Ontario, it is also suggested as an indicator for forest management practices and impacts from Far North development (Thompson pers. comm. 2013).

Wolverines are a much sought after and economically valuable furbearer (North Slave Metis Alliance (NSMA) 1999; WMAC(NS) and Aklavik HTC 2003; Cardinal 2004; Banci *et al.* 2005; ICC *et al.* 2006; GRRB 2014), and are trapped or hunted over much of their range in Canada (Table 1). The fur is frequently used for trim for garments due to its durability and frost-resistant characteristics (ICC *et al.* 2006).

Table 1. Wolverine pelts produced in the western sub-population, Canada, 1992/93 to 2010/11[1].

Season	ON	MB	SK	AB	BC	YT	NT[2]	NU[3,4]	Canada
1992/93	4	48	2	44	236	176	93	34	637
1993/94	6	76	12	27	97	117	121	29	485
1994/95	8	52	11	23	186	145	119	15	559
1995/96	18	45	7	9	135	72	59	5	350
1996/97	14	46	14	27	225	161	86	26	599
1997/98	12	66	10	50	152	118	175	24	607
1998/99	4	33	4	40	123	104	62	15	385
1999/00	4	18	6	10	160	157	99	22	476
2000/01	7	53	23	37	162	188	56	19	545
2001/02	7	39	14	19	183	110	111	33	516
2002/03	8	39	29	35	120	131	106	29	497
2003/04	6	43	17	23	119	138	132	41	518
2004/05	11	47	18	29	161	104	118	24	512
2005/06	6	32	14	24	123	106	126	54	485

Season	ON	MB	SK	AB	BC	YT	NT[2]	NU[3,4]	Canada
2006/07	2	24	18	43	120	106	154	30	497
2007/08	8	25	10	26	68	150	76	32	395
2008/09	7	52	18	26	123	142	133	39	540
2009/10	1	39	11	51	168	137	103	49	559
Total	133	777	243	543	2661	2362	1929	520	9162

1. Source: Statistics Canada, Fur Statistics. Statistics Canada does not publish Fur Statistics – Wildlife Pelts (Publication 23-013-X) after 2009/10. Data from 2010/11 and 2011/12 were not available from all jurisdictions at the time of writing. Minor provincial modifications to Wolverine harvest data were provided by BC (Weir unpubl. data 2012), SK (Koback 2012) and MB (Berezanski unpubl. data).
   These data include all Wolverines harvested (BC, YT, ON), or furs entering the fur trade (all others). In the latter case, fur held over to another season, furs used privately (personal or locally produced handicrafts), or furs taken by out-of-province/territory trappers are not accounted for. These discrepancies are believed to be small in the provinces, but large in some remote communities in NT and NU. See text for more information.
2. Wolverine harvest that goes through the fur auction is documented but Wolverine taken by sport hunters or use by Aboriginals are less reliably reported (*e.g.*, 19.2% reported in the Inuvialuit communities between 2001/02 and 2011/12) (Branigan and Pongracz unpubl. data 2012; Mulders unpubl. data 2013; Rossouw unpubl. data 2012; data summarized in NWT SARC 2013). Unreported Wolverine harvest also occurs in the Rennie Lake area by trappers from Saskatchewan who, between 2000/01 and 2008/09, exported an annual average of 38.7 pelts, or 25.6% of the combined harvest (Mulders unpubl. data 2013; data summarized in NWT SRC 2013). Mandatory reporting of hunted wolverine in the MacKenzie Mountains, NWT shows 31 harvested from 1991-2012 (Larter and Allaire 2013).
3. 19.3% of Wolverine harvest entered fur trade 1996-2001 in NU (Government of Nunavut 2007; Spencer unpubl. data 2012).
4. Statistics Canada pelt data collection began for Nunavut in 1992/93 for political reasons related to an Inuit land claim, in preparation for the establishment of Nunavut as a territory, which occurred on April 1, 1999.

Wolverines are important to the culture and mythology of numerous First Nations (*i.e.*, Gwich'in stories on naming Nehtryuh (Wolverine); GRRB 2001, 2014). Wolverines often are given derogatory names, such as Devil Bear and Skunk Bear, because of their propensity to rob food caches and cabins and then mark the area with their musky scent (Fortin *et al.* 2005). They frequently consume animals in a trap, and trap-wise Wolverines can be difficult to catch, earning them a range of responses from respect to contempt from trappers (GRRB 2001; Thorpe *et al.* 2001; Cardinal 2004; Ray 2004; Paul F. Wilkinson and Associates 2009). They are rarely seen, especially in forested areas (Cardinal 2004). Legendary attributes, such as ferocity and cunning, are common in mythology and folklore surrounding Wolverines (Holbrow 1976; Cardinal 2004; ICC *et al.* 2006; Paul F. Wilkinson and Associates 2009).

DISTRIBUTION

Global Range

Wolverines are found across the boreal regions of northern Eurasia and North America. The Eurasian range of the Wolverine includes Norway, Sweden, Finland, the Russian Federation, Estonia, Mongolia, and China. Range reductions have occurred in the European range south of 60°N.

Wolverine range in the conterminous United States has declined with human developments since the mid-19th century. They have been extirpated from the Great Lakes region, and from much of their range in the western mountains, where populations were naturally fragmented (Aubry *et al.* 2007). They ranged as far south as Colorado, Utah and California; however, small populations currently inhabit montane regions in Washington, Idaho, Montana and Wyoming (Figure 3; Aubry *et al.* 2007), with recent verified occurrences in Colorado (Inman *et al.* 2009), California (Moriarty *et al.* 2009), and Oregon (Magoun *et al.* 2013).

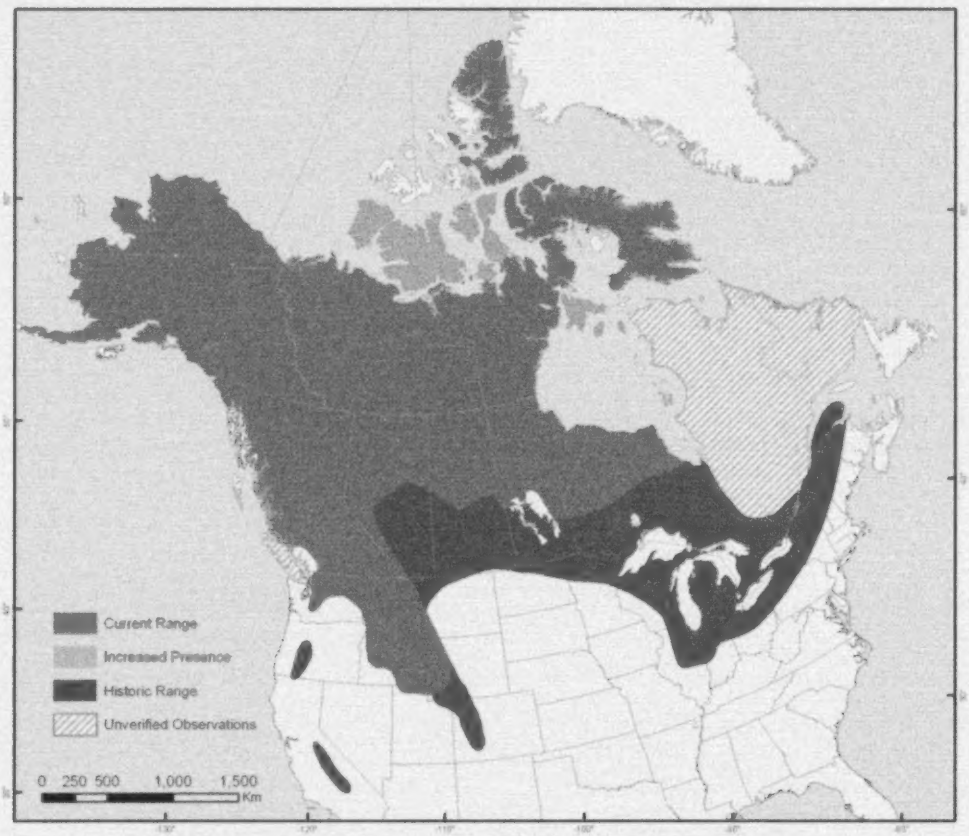

Figure 3. North American distribution of Wolverine. Adapted from COSEWIC (2003), Magoun *et al.* (2004), Ray (2004, 2012), Aubry *et al.* (2007), Thibault unpubl. data (2013). Map produced by Bonnie Fournier, NWT. Increased presence refers to observations of Wolverine on various islands, but it is not known if these are established or vagrant individuals.

The historical range of Wolverines in North America was compiled from anecdotal evidence such as personal accounts and the interpretation of fur returns. The two major fur trading companies, Hudson's Bay Company and the North West Company, traded over large areas (Novak *et al.* 1987; Obbard *et al.* 1987) and harvest locations cannot be confidently assigned to the community at which they were traded, or where they were trapped. Most of the southern areas from which Wolverines were presumably extirpated never produced significant numbers of Wolverine pelts (see Aubry *et al.* 2007). Human activities and habitat changes may have influenced the range contraction in the United States and Canada, but a northward shift in spring snow cover that persists through the reproductive denning period may be a critical factor as well (Copeland *et al.* 2010; see Habitat Trends section).

Canadian Range

Wolverine occur across much of the length of Canada, inhabiting forested areas, alpine tundra of the western mountains and arctic tundra (Figure 3). On the West Coast, Wolverines occur on Pitt (MacLeod 1950) and Princess Royale (Shardlow 2013) Islands, and were last confirmed on Vancouver Island in 1991 (BC Government 2013). Wolverines have not been reported on the island of Newfoundland, Nova Scotia, Prince Edward Island, Haida Gwaii, and some islands of the northwestern Arctic Archipelago in the NWT and Nunavut (Dauphiné 1989). Arctic islands supporting Wolverine include Victoria, Banks, Stefansson, Prince of Wales, Somerset, Devon, Cornwallis, Amund Ringnes, Ellesmere, Baffin, Bylot, Coates, Mansel (Community of Sachs Harbour *et al.* 2008; Environment Canada 2013; Carrière pers. comm. 2013), and it has recently been confirmed on Southampton Island (Awan pers. comm. 2013). Harvesters report a northwards expansion of wolverine (Cardinal 2004) with an increase in Wolverine on Victoria Island (Cardinal 2004; Banci *et al.* 2005), Baffin Island (Mallory *et al.* 2001), and Banks Island (Environment Canada 2013). Wolverine residency on some Arctic islands is unclear and is likely dependent on the availability of food resources.

Range reductions began in the mid-19th century, where it was extirpated from New Brunswick, and the southern half of Ontario and Québec, and from the aspen parkland of Manitoba, Saskatchewan and Alberta (Dauphiné 1989). In Labrador, range reduction began in the 1890s; between 1891-1910, 732 pelts were received at Fort Chimo and Davis Inlet, compared to 75 pelts between 1910-1930. The last verified record for Labrador was of two animals trapped in 1965 (Dagenais 1988). However, it is just as likely they persisted until the late 1970s because the last record for the entire eastern population was an animal trapped in 1978 in Schefferville, Québec, which is on the border with Labrador (Dagenais 1988; Fortin *et al.* 2005). Pelts were traded in Québec until 1980, but it is not known if they originated in Québec (Fortin *et al.* 2005).

Evidence from aerial surveys and trapper reports suggests a reoccupation of eastward range may be occurring in northern Ontario (Figure 4; Magoun *et al.* 2004; Ray *et al.* 2005; Koen *et al.* 2008; Ray 2012; Ontario Wolverine Recovery Team 2013; Ontario Ministry of Natural Resources, unpubl. data).

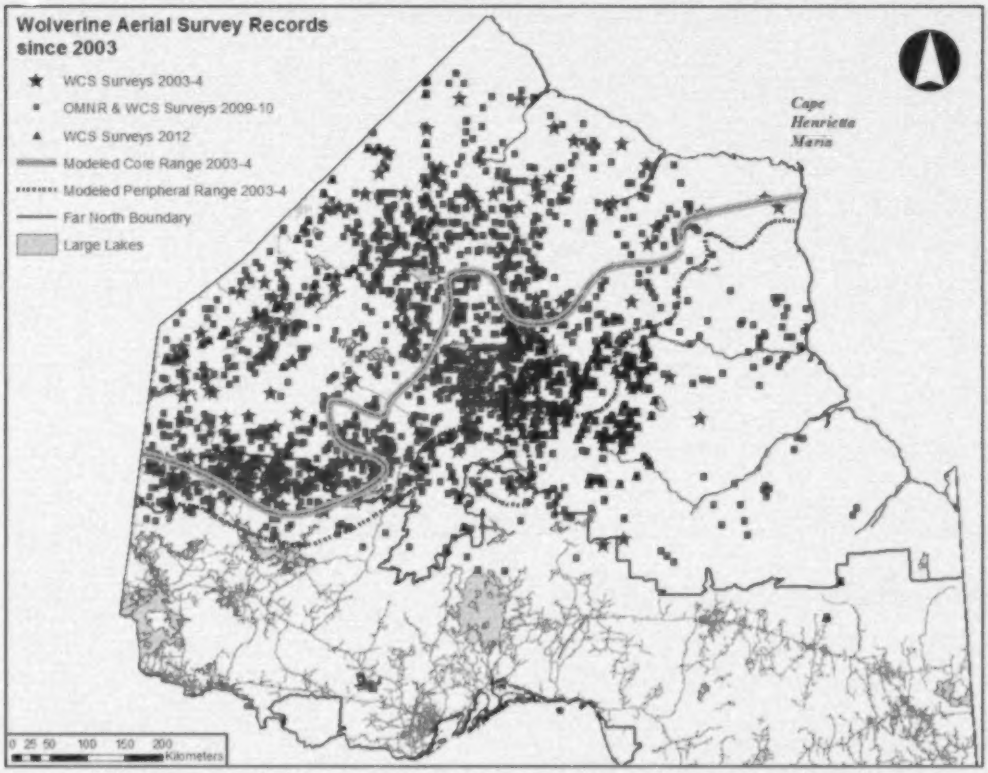
Wolverine Aerial Survey Records since 2003
WCS Surveys 2003-4
OMNR & WCS Surveys 2009-10
WCS Surveys 2012
Modeled Core Range 2003-4
Modeled Peripheral Range 2003-4
Far North Boundary
Large Lakes
Cape Henrietta Maria
0 25 50 100 150 200
Kilometers
Map prepared by Wildlife Conservation Society Canada. Data Source: Ontario Wolverine Project, a collaboration between the Ontario Ministry of Natural Resources, WCS Canada and The Wolverine Foundation.

Figure 4. Locations of Wolverine records based on aerial surveys conducted by Wildlife Conservation Society (WCS) and Ontario Ministry of Natural Resources (OMNR). The area west of the modelled core and peripheral range represents the main and peripheral locations of Wolverine before 2004. The large number of recent (>2009) records indicates an eastern expansion of the sub-population. (Source: Ontario Wolverine Recovery Team 2013; Ray unpubl. data.)

Extent of Occurrence and Area of Occupancy

'Extent of occurrence' (EO) is defined as the area included in a convex polygon that encompasses the geographic distribution of all verified (scientific and ATK) occurrences of the Wolverine. The EO of the Western Population of the Wolverine in Canada is > 10 million km². The EO of the eastern sub-population, based on recent, but unverified observations, would be 0.88 million km².

'Index of area of occupancy' (IAO) is defined as the area within the EO that is occupied by Wolverines, excluding cases of vagrancy. It is calculated based on 2 km x 2 km grid cells that intersect the actual area occupied by Wolverines. This measure reflects the fact that the EO may contain some unsuitable or unoccupied habitats. The IAO of Wolverines in Canada is > 4,000 km^2 for the western sub-population, and has not been determined for the unverified records in the eastern sub-population.

Search Effort

Wolverine distribution in Canada has been documented from several sources of information. Most data are derived from trapping activities. Registered trapping concessions or open trapping areas in BC, Alberta, and the Yukon correspond with area-specific harvest designation (Slough and Jessop 1996; Cardinal 2004; Jung *et al.* 2005; Arctic Borderlands Ecological Knowledge Coop Society (ABEKC) 2008; Slough 2009). In other jurisdictions, location of trap activity is recorded by nearest government office, trade centre, or through trapper surveys. ATK notes Wolverine are usually recorded during periods of snow cover but this likely relates to the period of trapping activities, which is biased to fall and winter. Most Wolverines are trapped incidentally (Cardinal 2004) and capture locations are rarely shared (ICC *et al.* 2006).

Techniques have been developed to determine the probability of Wolverine occurrence in a sample unit based on a hierarchical spatial modelling of Wolverine tracks in the snow (Schmelzer 2006; Magoun *et al.* 2007). Remote cameras have been used in many jurisdictions (Magoun *et al.* 2011a, b). Standard live-capture and radio-telemetry has been used in some area-specific studies to determine biological characteristics, such as home range size and movements, habitat use and density. Parks Canada and Department of National Defence maintain a database on Wolverine observations at their sites (Nantel pers. comm. 2012; Nernberg pers. comm. 2012).

Field studies to determine Wolverine population characteristics and/or density were conducted in the south-central Yukon from 1982 to 1985 (Banci 1987) and in the northern Yukon in 2004 (Golden *et al.* 2007). Wolverine DNA mark-recapture sampling has been undertaken in the diamond mining and exploration region northeast of Yellowknife since 2005 (Mulders *et al.* 2007; Boulanger and Mulders 2008, 2013a, b). Incidental observations are recorded at diamond mines in the NWT and Nunavut (NWT SARC 2013).

Diamond mining companies in the NWT (*e.g.,* Diavik Diamond Mines Inc., BHP Billiton-Ekati, De Beers-Snap Lake) have Environmental Agreements and Wildlife Effects Monitoring Plans. The recording of observations and winter track-counts began at Snap Lake in 1999 (Golder Associates 2010). The track-count technique was modified in 2003 to use multiple, 4 km long transects. At Ekati, a regional DNA-based study replaced the Wolverine snow track survey that was conducted from 1997 to 2004 (Rescan 2012). Snow track surveys began at Diavik in 2003, and the methods were revised in 2008, using standard 4 km straight line transects (Diavik Diamond Mines Inc. (DDMI) 2012). Wolverine sightings have been documented at Kennady Lake since 1998, and winter track-counts began in 2004 (Golder 2010).

The survey effort in Nunavut is very similar to that in the NWT; Wolverines are monitored using fur harvest data, carcass collections, field studies, and ATK. Wolverine fur is prized in Nunavut, where most of the pelts are used locally. Wolverine densities are being monitored at diamond mining areas at High Lake (near Coronation Gulf) and Izok Lake (near the NWT border) using the DNA mark-recapture technique (Poole unpubl. data 2013). Both of these study areas are in the Southern Arctic ecozone.

British Columbia monitors Wolverines using harvest data and a compulsory reporting system for trappers and hunters, which receives low compliance (Krebs pers. comm. 2013). Two field studies of Wolverine ecology took place in the Omineca Mountains of north-central BC between 1995 and 2001, and the Columbia Mountains of the southeast (Lofroth and Krebs 2007).

Alberta has used opinion surveys of trappers (Petersen 1997) and fur harvest data analyses (Webb *et al.* 2013). Fisher *et al.* (2013) used genetic tagging to document Wolverine density in the Willmore Wilderness Park in the Rocky Mountains (2006 to 2008) and in the foothills near Hinton and Grande Cache (2005 to 2006). Genetic tagging has been used in Banff and Yoho National Parks since 2010 (Clevenger *et al.* 2011a). Camera trapping has been used in the central Rocky Mountains (Kananaskis Country) since 2010 (Fisher and Heim 2012) and in Banff and Yoho National Parks since 2009 (Clevenger *et al.* 2011b).

Wolverine distribution and abundance in Saskatchewan are monitored using fur harvest statistics (Siemens Worsley 2011), trapper questionnaire responses (Gollop 2012), and ATK (Berezanski 2004).

In 2000/01 a zero quota was placed on non-aboriginal trappers in Ontario; however, legal trapping continued until 2009 when the Wolverine season was closed. First Nation trappers may still harvest Wolverine via treaty rights but have not be able to sell the pelts since 2009. Most information on Wolverine distribution and abundance has come from fur harvest reports (incidental and Aboriginal harvest), ATK (Ray 2004) and aerial surveys (Ontario Wolverine Recovery Strategy). Recent aerial surveys have improved our knowledge of Wolverine range in Ontario (Figure 4) (Magoun *et al.* 2004, 2007; Ray *et al.* 2005; Koen *et al.* 2008; Ray 2012; Ontario Wolverine Recovery Team 2013). The 2005 Ontario Wolverine Project study area covered approximately 60,000 km^2 in the Boreal Shield Ecozone in northern Ontario (Ray *et al.* 2005; Magoun *et al.* 2007; Bowman *et al.* 2010). Incidental Wolverine observations were recorded during a Caribou recruitment survey made across northern Ontario along a total transect length of 14,740 km in 2012 (Ray 2012). Knowledge of distribution is deemed robust, although incomplete along the range periphery (Ray pers. comm. 2013).

A study of Wolverine home range characteristics and ecology was conducted in lowland boreal forest near Red Lake, in northwestern Ontario in 2003-2004 (Dawson *et al.* 2010) along with a DNA mark-capture study, conducted in the same study area in 2004 by the Ontario Wolverine Project Team (Dawson *et al.* unpubl. data 2013). Data from these two studies have been used to estimate Wolverine density.

In Québec, Wolverine observations submitted since 2000 are numerous but unverified (Figure 5; Thibault unpubl. data 2013). An aerial survey for Wolverines in a 4,274 km^2 area of the proposed Monts-Torngat-et-de-la-Rivière-Koroc National Park where Wolverine had once been present did not find evidence of the species (Fortin 2004). Another survey in the Abitibi and James Bay lowlands (100,000 km^2) reported observations of two tracks in the area <100 km east of the Ontario border, but these

have not been verified (Fortin 2006; Thibault unpubl. data 2013). A Wolverine camera trapping project initiated in the Abitibi lowlands and Laurentian Mountains in 2012 has not recorded Wolverine, to date (Thibault pers. comm. 2012).

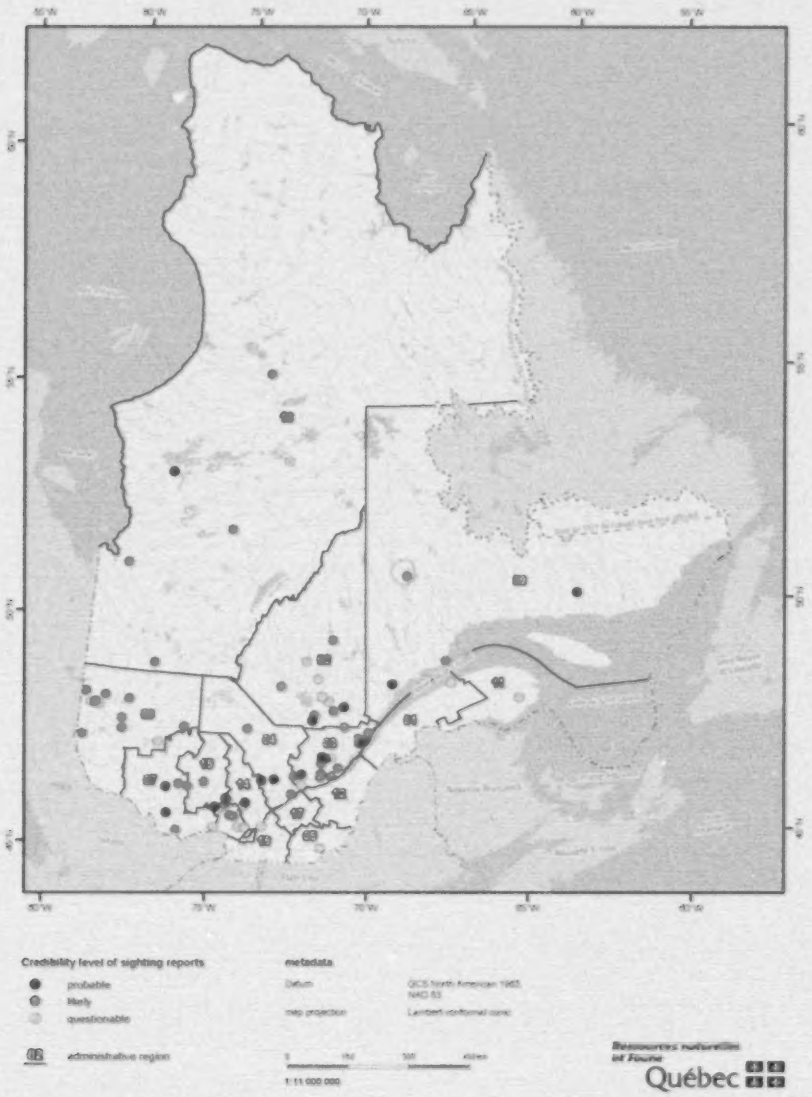

Figure 5. Locations of Wolverine sighting reports in Québec, 2000 to 2012, according to their relative level of credibility. No sightings have been verified. Adapted from Thibault unpubl. data (2013).

Johnson *et al.* (2012) assessed the Monts Groulx and Monts Otish in southeastern Québec for Wolverine denning habitat potential using GIS-based modelling of habitat variables, such as snow cover, summer snow persistence, the alpine-treeline ecotone, topographic ruggedness and distance from human activity. They concluded that the western massif of the Monts Groulx represented the highest quality reproductive habitat in sub-arctic Québec. A province-wide survey of Wolverine habitat potential in Québec also identified the Torngat Mountains, a large part of the Côte-Nord, the southeast section of the Nord-du-Québec, and part of the Charlevoix region as having potential to support Wolverines (Gallais and Messier 2012).

In Labrador, historical accounts are based on Hudson's Bay Company fur trade data from posts in Davis Inlet and Moravian Missions of Hebron and Okak from 1884 to 1923 Schmelzer (unpubl. data 2012). The harvest of Wolverines was banned in Labrador (mainland Newfoundland and Labrador) in 1950. Aerial surveys, using 1,000-km^2 hexagons, were conducted in 2005. The total transect length was 6,630 km, covering an area of 195,000 km^2 between 54°N and 60°N and approximately 80% of Labrador and much of the range of the eastern population (Schmelzer 2006). Anecdotal observations continue to be reported; however, none have been verified by photographs or genetic analysis. A follow-up protocol, including search for hair samples, exists to attempt to verify observations (Moores pers. comm.). Inuit and Metis Aboriginal communities conduct ground detection monitoring using hair snag stations and remote cameras to try to verify reported sightings in the Cartwright area, and in northern Labrador (*e.g.,* Habitat Stewardship Project by NunatuKavut Community Council; MacDonald pers. comm. 2013; Moores pers. comm.).

Anecdotal observations, including sightings of Wolverines and Wolverine tracks, are often ranked according to their reliability (*e.g.,* Aubry and Houston 1992). A reliability ranking method is employed in the range of Eastern Wolverine Population in Québec (Thibault pers. comm. 2012).

HABITAT

Habitat Requirements

Wolverines inhabit a variety of treed and treeless vegetation associations (ICC *et al.* 2006), at all elevations, although some Aboriginal harvesters suggest that they find more Wolverines in higher elevation areas (Wildlife Management Advisory Council (North Slope) (WMAC (NS)) and the Aklavik Hunters and Trappers Committee (HTC) 2003; Cardinal 2004; GRRB 2014) and fewer in open tundra (Cardinal 2004). They thrive in ecologically intact areas, where prey and other carnivore species are common and diverse. Wolverine habitat components include food (Cardinal 2004) and suitable physical features for natal and maternal den sites, and rendezvous sites, where kits are left during foraging periods by the female. In a multi-scale habitat use study in two multi-use regions of British Columbia, male Wolverines chose vegetation associations primarily based on food availability in summer and winter, while females were influenced by food, predation risk, and disturbance (Krebs *et al.* 2007).

Wolverine locations recorded by Mulders (2000) in the Southern Arctic ecozone in the NWT were correlated with vegetation density and patches, especially sedge density (Johnson *et al.* 2005). The reason for this association is unclear, but Wolverines were also associated with Wolves (*Canis lupus*), Caribou (*Rangifer tarandus*) and Grizzly Bears (*Ursus arctos*). Viable populations of large carnivores such as Grizzly Bears and Wolves are important as involuntary providers of ungulate carrion.

In mountainous areas, adult females used higher elevation alpine vegetation associations and steeper terrain more than males or other age classes (GRRB 2001; Cardinal 2004), while adult males and subadults of both sexes made extensive use of low elevation forested areas (Krebs *et al.* 2007). Lower elevations are used more in winter by males, and both sexes use all elevations in summer (Landa *et al.* 1998; Copeland *et al.* 2007; Krebs *et al.* 2007). Banci and Harestad (1990) found that Wolverines in the Kluane Game Sanctuary used vegetation associations according to availability, although males used coniferous subalpine areas more frequently than other vegetation associations in winter.

Den Sites

Wolverines have specific physical requirements for den sites. Dens are constructed either in talus boulders, along eskers, under deadfall, under logs in avalanche debris, or in snow tunnels at higher elevations and tundra (Copeland 1996; Magoun and Copeland 1998; GRRB 2001; WMAC and Aklavik HTC 2003; Cardinal 2004; Inman *et al.* 2007). Wolverine dens are also associated with large boulders and downed trees at lowland boreal sites in Ontario and Yukon (Dawson *et al.* 2010; Slough unpubl. data). In the eastern Arctic, Wolverines den in rocky areas with boulders, while in the western Arctic, knowledge holders describe finding dens in snow banks, under tree roots and along streams throughout the boreal region (GRRB 2001; Lutsël K'e Dene First Nation *et al.* 2001; WMAC(NS) and Aklavik HTC 2003; Cardinal 2004). It was reported that reproductive dens are often found in similar areas as dens used for other purposes (Cardinal 2004), although reproductive dens were usually less accessible and more isolated (GRRB 2001; ICC *et al.* 2006).

The availability of adequate insulating snow cover (*i.e.* ≥1.0 m deep) late into spring appears to be an important habitat feature for denning (Magoun and Copeland 1998). Copeland *et al.* (2010) found that 97.9% of 562 reproductive dens that they investigated in Fennoscandia and North America occurred at sites with persistent spring snow cover in at least 1 of 7 years. Female Wolverines must leave their kits for lengthy foraging trips, and often select natal den sites in talus or avalanche debris with snow cover late into spring (Copeland 1996; Inman *et al.* 2007) or under remnant snowdrifts (Magoun 1985). Such snow accumulation typically occurs in ravines and on leeward slopes. Dens with spring snow cover allow Wolverines to construct snow tunnels that provide thermoregulatory benefits for kits, are secure from excavation by predators, while dens are located in areas used by few other carnivores, and also provide an abundance of small-mammal prey for feeding kits (Magoun and Copeland 1998).

Individual Wolverines may reoccupy den sites or denning areas for several consecutive years (Magoun 1985; Inuit hunters, as reported by Lee and Niptanatiak 1996). Wolverine reliance on food caching in cold, structured microsites to inhibit competition with insects, bacteria, and other scavengers is likely a critical behavioural adaptation due to the limited availability of food resources. Inman *et al.* (2012) suggest that habitat features that facilitate caching, including low ambient temperatures, are likely important and related to the distributional limits of the Wolverine.

Habitat Trends

Considerable Wolverine habitat was permanently lost or fragmented with the extensive human development that occurred in the late 19th and 20th centuries at the southern edge of the range (van Zyll de Jong 1975). Much of the habitat lost may have been low quality habitat (as evidenced by low fur harvest returns), and numerical losses of Wolverines may have also been low. Losses were due primarily to human settlement and agriculture, with associated reductions due to hunting and trapping. Many Wolverines likely were non-target kills from poison baits used during predator control directed at wolves.

The reduction of ungulates, an important winter prey base, also likely contributed to their range contraction. Reduced numbers of prey remains a significant threat to Wolverine populations today, especially where Central and Southern Mountain, and southern Boreal Caribou herds are declining (Lofroth *et al.* 2007). Increases in Moose (*Alces alces*) and deer (*Odocoileus* spp.) populations in logged areas may, in part, compensate for losses in Caribou numbers. Wolverines may suffer from the recent declines of many Barren-ground Caribou herds (Vors and Boyce 2009). For example, the Bathurst herd declined from 203,800 to 16,400 breeding females from 1986 to 2009 (Boulanger *et al.* 2011). The Eastern Migratory George River herd of northern Québec and Labrador has declined from a high of > 600,000 in the 1980s to 27,600 animals in 2012 (Newfoundland and Labrador Department of Environment and Conservation 2012).

A positive correlation between Wolf and Wolverine harvests at trading posts in Québec and Labrador suggests that current-day Wolf population dynamics may be a useful tool to evaluate Wolverine recovery potential (Schmelzer unpubl. data 2012). However, Wolves in Labrador/Québec slowly recovered in the last century following the collapse and subsequent recovery of Eastern Migratory Caribou in the region, while Wolverines did not. The increase in Caribou that favoured the Wolf should also favour the Wolverine; reasons for the lack of a recovery by Wolverine in this region remain unknown.

Habitat fragmentation has resulted in isolated and threatened Wolverine populations in the western conterminous US (Banci 1994), and this process may be occurring in southern BC and Alberta, and in Manitoba and Ontario (Kyle and Strobeck 2002; Zigouris *et al.* 2012). Across parts of Wolverine range, forestry, oil and gas and mineral exploration and development, and large hydroelectric reservoirs threaten habitat with permanent, temporary and functional losses. Transportation corridors can act as barriers to movement and fragment habitats and isolate populations. Direct mortality may be a factor along transportation corridors in southern range, and elsewhere roads facilitate indirect mortality through improved motorized access for hunters, trappers and recreational users into remote areas. Travel and dispersal corridors of suitable vegetation associations must be maintained to facilitate connectivity of populations (*e.g.*, Schwartz *et al.* 2009).

Kelsall (1981) and Dauphiné (1989) assumed that the relatively large number of parks and protected areas, which act as refugia from trapping and development in western Canada, had secured Wolverine populations. Trapping by Aboriginals, however, is allowed in most northern protected areas, and many Wolverines range outside protected area boundaries where they are vulnerable to trapping (Squires *et al.* 2007). Furthermore, human recreation, such as snowmobiling and other forms of snow travel allowed in some parks, may disturb Wolverines, particularly during the denning season in February-March (Heinemeyer and Squires 2012).

A study of the cumulative effects of developments on Arctic wildlife (Johnson *et al.* 2005) found that mines and other major developments had the largest negative effect on species occurrence, followed by exploration activities, and outfitter camps. The species most affected were Grizzly Bears and Wolves, followed by Barren-ground Caribou and Wolverines. The response by Wolverine was based on relocated Wolverine in the Slave lake area (Mulders 2000) which experienced a 2.4% decrease in use of summer habitat, likely because of a strong interaction between Wolverine and Caribou during the summer, when Caribou strongly avoided developments.

The extent of habitat loss from climate change is uncertain. Wolverine den in snowpack areas (see **Den Sites** section) and spring snow cover during the denning period is closely related to historical Wolverine distribution in the contiguous United States (Aubry *et al.* 2007). Brodie and Post (2010a, 2010b) hypothesized that the declining snowpack in western Canada for the years 1974-2004 negatively affected Wolverine population dynamics, as evidenced by declining harvests. However, numerous biases could also explain declining harvests, such as trapping effort, declining pelt prices and licence sales, changes in trapping regulations, and trapper success, which raised questions about the validity of their conclusions (DeVink *et al.* 2010; McKelvey *et al.* 2010). A recent panel of experts generally agreed that snow is important at the scale of the den site, but did not agree if snow was limiting at the home-range, or species-range scales (Wolverine Science Panel 2014).

A climate-driven decline is not evident at this time in much of Wolverine range because Wolverine population trends in the northern range, while largely unknown, are possibly stable or increasing in many areas (COSEWIC 2003; Krebs *et al.* 2004; Lofroth and Krebs 2007; Slough 2007; see **Abundance and Trends** section). There is greater concern for southern areas of BC, and mountainous areas of the northern US (Weir pers. comm.; Wolverine Science Panel 2014); reductions in spring snow cover associated with climatic warming will likely reduce the extent of Wolverine habitat in the U.S. (McKelvey *et al.* 2011). Reductions in spring snow cover for lowland or mountain habitats in Canada have not been assessed specifically for Wolverine, but significant declines in sub-boreal and high altitude ecosystems are expected due to climate shifts (Wang *et al.* 2012).

BIOLOGY

Biological factors, such as a relatively low intrinsic rate of increase, low natural densities, and large home ranges limit population growth rates and affect the Wolverine's ability to recolonize vacant habitats and recover from trapping (Banci and Proulx 1999). Re-population may take several decades but is possible in areas where factors (such as cessation of predator poisoning, trapping regulations, and ungulate population growth) favour Wolverine survival (Johnson 1990; Vangen *et al.* 2001).

Life Cycle and Reproduction

Wolverines have a polygamous mating system, with males mating with more than one female. Most Wolverines become sexually mature at 2 years of age, but few breed at this age (Banci 1994). Wolverines are thought to breed in the summer, from June through August (Magoun and Valkenburg 1983; Krott and Gardner 1985), and ATK suggests they breed during a few weeks in March and April during a period of active movement (GRRB 2001; Cardinal 2004; Deh Cho First Nation 2006). The proportion of adult female that were pregnant ranged from 74% (Banci and Harestad 1988) to 92% (Rausch and Pearson 1972) in studies in Yukon and Alaska. The pregnancy rate of subadults (1-2 years old) was 7% in the Yukon (Banci and Harestad 1988) and 50% for a combined Alaska/Yukon sample (Rausch and Pearson 1972). The latter study might have included some adults (Banci 1994). The pregnancy rate declined from 92% for 2-3 year olds to 53% for 5-6 year olds and 37% for combined 6 year old and older age classes. Recent (2005/06-2011/12) analyses of Wolverine carcasses from the Yukon showed a pregnancy rate of 0% for juveniles, 31% for yearlings, and 80% for adults. The highest pregnancy rates (90%) were in 3-5 year old animals (Jung and Kukka 2013).

The average number of fetuses ranged from 2.8 (2-3 year olds) to 3.4 (6+) in a 1980s Yukon study (Banci and Harestad 1988). Litter size was greatest for females over the age of 6 (Banci and Harestad 1988; Rauset 2013), but the pregnancy rate for that age class was lower. Overall reproductive rates observed in Alaska and Idaho were 0.69 and 0.89 kits per female per year, respectively (Magoun 1985; Copeland 1996); the low values reflect that females often breed every other year. Litter size was closely tied to primary productivity (Rauset 2013).

Active gestation takes 30-40 days (Rausch and Pearson 1972). Litters of four or less are born between January and April (Banci and Harestad 1988), or as late as June or July (GRRB 2001; Cardinal 2004). Wolverine kits reach adult body size by 7 months of age (Magoun 1985) and are weaned at 9-10 weeks (Banci 1994).

In this report, generation time is based on the average age of reproductive females in the population. The maximum age reported for Wolverines is 16 years in the Inuvik Region, NWT (Branigan and Pongracz unpubl. data 2012). Maximum ages of 11 were reported in the Kitikmeot Region, Nunavut (Lee 1998), and 12.9 in the Yukon (Jung and Kukka 2013). Most females do not breed until the age of 3, and the average age of females that are 3 or older is likely 7 or 8 years of age. The generation time for Wolverines is likely 7.5 years.

Physiology and Adaptability

Wolverines typically occupy home ranges that vary from about 50-400 km^2 for females, and 230-1580 km^2 for males (Hornocker and Hash 1981; Gardner 1985; Magoun 1985; Whitman *et al.* 1986; Banci and Harestad 1990; Copeland 1996; Krebs *et al.* 2007; Dawson *et al.* 2010; Persson *et al.* 2010). Lofroth (2001) documented an average home range of 1,230 km^2 for subadult females, and a range of 3,500 km^2 for dispersing subadult males. WMAC(NS) and Aklavik HTC (2003) report that fresh tracks of solitary Wolverine are observed in about every 40-80 km of snowmobiling in April and May. There may be home range overlap between members of the same and opposite sexes, with the latter being more common (Krebs and Lewis 2000). Cardinal (2004) reported that male home ranges would include the ranges of 4-5 females. Aboriginal and Inuit harvesters indicate that wolverine move extremely large distances (NSMA 1999; Cardinal 2004; ICC *et al.* 2006; Henry 2007) and that they are unclear if they have a home range or territory because they never seem to stay in the same area (Cardinal 2004). Some knowledge holders believe that older Wolverines establish home ranges, but younger individuals do not (Cardinal 2004; Henry 2007).

Wolverines show some adaptability to humans, being attracted to wilderness camps, traplines, and snowmobile trails by virtue of their scavenging habits. There is also a negative impact of disturbance, leading to the loss of functional habitat, possibly affecting the reproductive success of females (see **Threats and Limiting Factors** section).

Dispersal and Migration

A proportion of the population, typically yearlings, is transient at any given time. Yearling females tend to establish home ranges nearer their natal ranges than do yearling males, although both sexes are capable of long-distance movements. Male dispersal records include 200-874 km over several months (Gardner *et al.* 1986; Inman *et al.* 2004). A dispersal distance of 100 km was reported for a juvenile male in Ontario (Dawson *et al.* unpubl. data 2013). Maximum movements by females of 225-300 km have been recorded (Mulders 2000; Aubry *et al.* 2012).

Wolverines are able to traverse rugged terrain, including tundra and glaciers that would act as barriers to the dispersal of many other species of mammals. Long-distance dispersal abilities likely gave Wolverines the capacity to recolonize gaps in their distribution in Scandinavia (Vangen *et al.* 2001; Flagstad *et al.* 2004).

Interspecific Interactions

Wolverines are scavengers and predators, opportunistically feeding on abundant or readily procurable food (Cardinal 2004; Clément 2009; Benson 2011; Inman *et al.* 2012). Food is frequently cached for later use. Diets of Wolverine typically vary between seasons and years, as they switch between food sources depending on availability (Dalerum *et al.* 2009). Fresh prey are eaten more during summer and carrion, including cached items, is used more in winter (Magoun 1987). Many species of small mammal and ground-nesting bird are depredated. The most common sources of carrion are whichever large ungulate species are present (Gardner 1985; Banci 1987; Magoun 1987; Johnson and Ruttan 1993; NSMA 1999; Mulders 2000; GRRB 2001; Thorpe *et al.* 2001; Cardinal 2004; Ray 2004; Banci *et al.* 2005; Dumond 2007; Henry 2007; Lofroth *et al.* 2007; Clément 2009; Carriere 2010; Benson 2011).

In the Kitikmeot Region, Nunavut, Mulders (2000) reported that Caribou remains were found in 62% of stomachs of winter-trapped Wolverines, and Muskox were found in 11%. Minor food items included Arctic Ground Squirrels (*Spermophilus parryii*), voles and lemmings, and ptarmigan. Caribou were also the most common prey in the Inuvik Region, NWT (Branigan and Pongracz unpubl. data 2012), where they were found in 58% of Wolverine stomachs. Barren-ground Caribou were found in 56% of all stomachs in the North Slave Region, NWT (Mulders unpubl. data 2013), but were found in 12 to 32% of Wolverine stomachs from other regions. Snowshoe Hare (*Lepus americanus*) (and presumably Arctic Hare (*L. arcticus*) in tundra regions) is an important food for Wolverine in the north (Banci 1987; Branigan and Pongracz unpubl. data 2012) and a delayed numerical response of a 2-3 year time lag in Hare abundance has been documented (Bulmer 1975). Arctic Ground Squirrels are an important summer food in the Arctic (Magoun 1987). Several fish and seal species are scavenged (Golder Associates 2003; Cardinal 2004; Banci *et al.* 2005; Clement 2009). Porcupine (*Erethizon dorsatum*) are noted as a common food item in the Gwich'in Settlement region of the Mackenzie Delta (GRRB 2001, 2014).

Large carnivores generate carrion, which is an important food source for Wolverines, especially during the winter months (Wright and Ernst 2004). Carnivores also may compete with Wolverines at kill sites, and are a potential source of Wolverine mortality (White *et al.* 2002; Krebs *et al.* 2004; Jung and Kukka 2013). Johnson *et al.* (2005) found that Wolverines were positively associated with Wolves, Grizzly Bears and Caribou on the Slave study area, near Daring Lake, NWT, although a traditional knowledge study in the area of Wood Buffalo National Park did not report any cases of Wolverine preying on Caribou (Gunn 2009).

Wolverines are preyed on by Grizzly Bear, Polar Bear (*Ursus maritimus*), Wolves, Mountain Lions (*Puma concolor*), Golden Eagles (*Aquila chrysaetos*), and other Wolverines (Cardinal 2004). They may encounter large carnivores with greater frequency when scavenging carrion. Krebs *et al.* (2004) found that human-caused mortality from trapping and road/rail kill accounted for 46% of deaths in a review of 12 studies using radio-collared animals. Natural sources of mortality included predation by Wolves, Mountain Lions and conspecifics (30% of non-human causes), and starvation (49% of non-human causes).

Parasitic nematode roundworms (*Trichinella* spp.) were found in 88% of Wolverine samples tested from Nunavut (Reichard *et al.* 2008a) and 26% (n=43) of samples from the lower MacKenzie region (Larter pers. comm), and none (n=38) from the upper Mackenzie region (Addison and Boles 1978). Six other species of helminth parasites (trematodes, cestodes and nematodes) were recorded in the digestive tracts of Wolverine from the lower Mackenzie River valley (Addison and Boles 1978). Protozoan parasites (*Sacrosystis* spp.) infected 80% of Wolverines from Nunavut (Dubey *et al.* 2010). Another protozoan parasite, *Toxoplasma gondii*, was detected in 41% of Wolverines from Nunavut (Reichard *et al.* 2008b). The prevalence of clinical disease symptoms is unknown, but this parasite is transmissible to humans through skinning and fur handling. A rabid Wolverine (infected with a strain of Arctic Fox (*Alopex lagopus*) rabies) was recorded in Alaska (Beckman pers. comm. 2012). Rabies was not recorded in 71 Wolverine tested for rabies in the Yukon during recent years (Jung pers. comm. 2013).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Establishing population abundance and trends is difficult because most numeric data are derived from harvest activity. It is unknown in large parts of the range whether harvest actually reflects total harvest levels. Fur harvest is susceptible to many factors other than the population size of furbearers, including environmental, social, cultural and economic factors (Slough and Jessup 1996). Trends are difficult to establish if trap effort and reporting varies over time and by jurisdiction. For example, Lee (1994a) believed that the harvest was underestimated by 50-90% in Nunavut/NWT. Some reports suggest that <20% of the harvest enters the fur trade (Government of Nunavut 2007;

Spencer unpubl. data 2012). Based on carcass collection programs, the unreported harvest may be underestimated by 35% overall, and greater than 80% in Inuvialuit/Inuit coastal communities (Branigan and Pongracz unpubl. data 2012; Rossouw unpubl. data 2012; Mulders unpubl. data 2013; summarized in NWT SARC 2013). Lee (1994a) estimated that the actual harvest was underestimated by 50-90% in the Coppermine, Bay Chimo, and Bathurst Inlet area. (Note: although reporting is low, extra information on harvest is obtained with community-based carcass collections using cash incentives and may give an improved estimation of total area-specific Wolverine harvest (Lee 1994a, 1994b, 1998; Elliot and Dumond 2005; Branigan and Pongracz unpubl. data 2012; Mulders unpubl. data 2013)).

Although it is common to infer trend from harvest statistics, it may be problematic to base trend data upon the premise that current harvest is sustainable. In BC, for example, application of such a population model would have calculated population estimates in the 1970s near 10,000 Wolverine, rather than the 3,500 actually present (Lofroth pers. comm. 2012).

Provinces and territories which allow trapping and hunting of Wolverines maintain harvest records, but laws regarding the reporting of harvests vary greatly among jurisdictions. In the best cases, all harvested Wolverines are accounted for by one or more methods—mandatory pelt sealing, compulsory reporting, fur export permits or fur dealer records—and the harvest location of each animal is recorded. Jurisdictions using this type of harvest monitoring are BC, Alberta and Yukon.

Other jurisdictions monitor harvest using fur dealer records and export permits, which only capture furs exported to fur auctions. Depending on the local culture and traditions of the harvesters, varying proportions of the harvested pelts are retained for personal use, or for use in locally produced handicrafts. For example, much of the Inuvialuit/Inuit harvest of Wolverines across the Arctic (Yukon, NWT and Nunavut) is not sold at auction (Branigan and Pongracz unpubl. data 2012; Rossouw unpubl. data 2012; Mulders unpubl. data 2013).

Trapper questionnaire responses are sometimes converted to numerical values and compiled as Wolverine abundance and trend indices to provide a way to compare trappers' interpretations of species abundance and trends in a given area over time (Slough 2009). Some of the data limitations originate from the lack of standardization of trappers' perceptions, and animal behaviour patterns independent of population densities which affect perceptions of abundance (Jung *et al.* 2005). Verification with other data such as fur harvest and population surveys is recommended.

Abundance and Trends

ATK suggests that Wolverine are widespread, but not abundant (Cardinal 2004). The Gwich'in considered Wolverine to be scarce, both today, and in the past, and Wolverine do not appear to have the same population cycles seen in other furbearers (GRRB 2014). Most information from non-ATK sources is based on harvest data from

within the last 200 years. The earliest Wolverine harvest data attributed to specific Canadian jurisdictions indicate that populations, based on harvest success, may have been declining in the Prairie Provinces in the 1920s and 1930s (Novak *et al.* 1987). Ontario, Québec and Labrador harvests were already low by that time. Wolverine harvests in northern Québec and Labrador declined in the 1914-1923 period (Schmelzer unpubl. data 2012). Wolverines had been extirpated from New Brunswick by the early 1800s.

Wolverine densities vary across ecological areas, to a maximum of about 10 Wolverines/1,000 km^2 in North America (Table 2). The highest densities occur in Northern Mountain, northern Boreal and eastern Southern Mountain ecological areas and in the Southern Arctic Ecozone (5 to 10/1,000 km^2), where vegetation associations, prey species, ungulates, and large carnivores are most diverse and abundant. Moderate densities occur in the southern Boreal ecological area (1 to 3/1,000 km^2). There have been no field studies in the Pacific and western Southern Mountain ecological areas and Northern Arctic Ecozone, where densities are presumed to be low.

Table 2. Wolverine density estimates from North American studies.

Density (per 1,000 km^2)	Location	Study Area (km^2)	Relative Habitat Quality	National Ecological Area or Ecozone	Methods	Reference
6.5 (SE = 1.9)	Omineca Mountains, northern BC	8,900 km^2	High	Northern and Southern Mountain	Mark-recapture and mark-resight (cameras)	Lofroth and Krebs 2007
5.8 (SE = 1.1)	Columbia Mountains, southern BC	7,000 km^2	High	Southern Mountain	Mark-recapture and mark-resight (cameras)	Lofroth and Krebs 2007
0.3 - 2.0 - 4.1	BC	na	Rare, Low and Moderate	Pacific, Boreal, and Southern Mountain (plateau regions)	Predictions based on habitat quality ratings	Lofroth and Krebs 2007
4.8	Northeast BC	51,200	Moderate	Boreal	Trapper catch and snow tracking	Quick 1953
6.8	Willmore Wilderness Park, AB	4,600	High	Southern Mountain	DNA mark-recapture (NGT, non-invasive genetic tagging)	Fisher *et al.* 2009
3.0	Foothills, AB	6,400	Moderate	Boreal	DNA mark-recapture (NGT, non-invasive genetic tagging)	Fisher *et al.* 2009
5.6	Kluane Wildlife Sanctuary, YT	1,800	High	Northern Mountain	Based on known residents only, identified by live capture and telemetry	Banci and Harestad 1990
10.8	Kluane Wildlife Sanctuary, YT	1,800	High	Northern Mountain	Calculated from mean home range size and assuming saturated habitat	Banci and Harestad 1990
9.7 (CV 6.5%)[2]	Old Crow Flats, YT	3,375	High	Northern Mountain	Quadrat sampling of tracks in snow using sample-unit probability estimator (SUPE)	Golden *et al.* 2007

Density (per 1,000 km^2)	Location	Study Area (km^2)	Relative Habitat Quality	National Ecological Area or Ecozone	Methods	Reference
Declining 10.73 (CV 10.9%) to 3.72 (CV 15.4%)	Daring Lake, NT	2,556	Moderate to high	Southern Arctic Ecozone	DNA mark-recapture	Mulders *et al.* 2013b
Declining 11.43 (CV 18%) to 3.87 (CV16%)	Diavik, NT	1,269	High	Southern Arctic Ecozone	DNA mark-recapture	Boulanger and Mulders 2013a
Declining 10.05 (CV 19%) to 6.14 (CV 15 %)	Ekati, NT	1,062 to 1,647	High	Southern Arctic Ecozone	DNA mark-recapture	Boulanger and Mulders 2013a
4.6-5.2 (SE=1.3 F-2.4 M) [1]	Kennady Lake, NT	1,575	Moderate to High	Southern Arctic Ecozone	DNA mark-recapture	Boulanger and Mulders 2008
6.85 (SE=1.05) 3.5 F, 3.3 M	High Lake, NU	3,000	High	Southern Arctic Ecozone	DNA mark-recapture	Poole unpubl. data 2013
4.80 (SE=0.8) 1.5 F 3.3 M	Izok Lake, NU	3,000	Moderate to High	Southern Arctic Ecozone	DNA mark-recapture	Poole unpubl. data 2013
0.7-1.4	Red Lake, ON	7,626	Low to Moderate	Boreal	DNA mark-recapture and mean home range size	Dawson, Magoun, Ray and Bowman unpubl. data 2004 and 2013
USA						
9.7 (5.9–15.0)	Southeast Alaska (AK)	2,140	High	Pacific	Camera trapping and spatial capture-recapture model	Royle *et al.* 2011
3.0 (CV 12.0%)[2]	South-central AK	4,340	Moderate	Maritime montane (N. Kenai Mtns)	SUPE	Golden *et al.* 2007
5.2 (CV 20.3%)[2]	South-central AK	1,871	High	Maritime montane (N. Chugach Mtns)	Transect intersect probability sampling (TIPS)	Becker 1991
4.7 (CV 13.0%)[2]	South-central AK		Moderate	Montane (E. Talkeetna Mtns)	TIPS	Becker and Gardner 1992
4..0 – 7.4	South-central AK		Moderate to high	Montane (Susitna River Basin)	Home range/telemetry	Gardner and Ballard 1982
4.9 (CV 8.9%)[2]	South-central AK	3,663	Moderate	Maritime montane (W. Chugach Mtns)	SUPE	Becker and Golden 2008
4.6[2] (no variance est.)	South-central AK	1,050	Moderate	Maritime montane (W. Chugach and N. Kenai Mtns)	Total count of small study area	Golden 2010
5.0 (CV 17.1%)[2]	South-central AK	1,939	Moderate to high	Maritime montane (N. Kenai Mtns)	SUPE	Golden unpubl. data 2013
7.2	Arctic AK	~5,000	High	Arctic, western Brooks Range	Home range/telemetry	Magoun 1985
20.8 (fall estimate)	Arctic AK	2,400	High	Arctic, western Brooks Range	Home range/telemetry	Magoun 1985
4.0-11.1	Idaho	8,000	Moderate to High	Montane	Live capture, telemetry and reproductive potential	Copeland 1996
15.4[3]	Montana	1,300	High	Montane	Capture and snow tracking	Hornocker and Hash 1981

1. Standard errors given for density estimates for males and females in 2004, 2005 and 2006.
2. Surveys based on the TIPS or SUPE techniques should be considered minimum population estimates, because they are conducted in late winter/early spring, after trapping mortality and dispersal have occurred (Golden unpubl. data 2012).
3. May be overestimated due to edge effect of small study area (Lofroth and Krebs 2007) and may have included juveniles (Banci and Harestad 1990).

The following discussion of Wolverine population status is organized by jurisdiction, where sources of information from management programs and research projects vary greatly. Population estimates are provided but their accuracy may vary by jurisdiction.

Yukon Territory

All Wolverine pelts taken by Yukon trappers and hunters must be sealed, including pelts held over or used in the territory. Available evidence points to a stable population in all regions of the territory and a full recovery from the large-scale Wolf control programs (poisoning through the 1970s and aerial shooting through the 1990s). Trappers and/or Aboriginal knowledge holders report Wolverines to be generally common (Cardinal 2004; Henry 2004; ABEK 2008), and harvests are not declining relative to trapping pressure (Table 1). WMAC (NS) (2008) reported a harvest of about 10 Wolverines per year by Inuvialuit trappers from Aklavik, NWT.

Banci and Harestad (1990) estimated Wolverine density to be 10.75/1,000 km^2 in continuous and saturated habitat in the south-central Yukon. Golden *et al.* (2007) estimated a population density of 9.7 Wolverines/1,000 km^2 on the Old Crow Flats, Yukon. The estimate was 5.65/1,000 km^2 when using known Wolverines (assuming variable habitat quality and not all habitat is saturated). They estimated the resident population for about 85% of the territory to be 2,503 Wolverines, and a fall population of 4,171, including juveniles and transients (Banci 1987). The estimate was based on habitat suitability estimates (area trapped, trapper-years and numbers of Wolverines harvested), which likely underestimated Wolverines in remote areas where trapping effort is less than near communities. A more realistic Wolverine population estimate for the Yukon, based on 100% coverage of the territory and more homogeneous densities in high quality habitats, is 3,500 to 4,000 residents.

Northwest Territories

Wolverines are described as widespread, but not numerous in the NWT (WMAC(NS) and Aklavik HTC 2003; Community of Inuvik *et al.* 2008; Community of Paulatuk *et al.* 2008; Community of Tuktoyaktuk *et al.* 2008). Large numbers of Barren-ground Caribou and Wolves in the taiga and tundra associations indicated that Wolverines may be as common as they are elsewhere (Cardinal 2004; Mulders *et al.* 2007).

Wolverine densities declined on three study areas in the NWT between 2004-2005 and 2011 (Boulanger and Mulders 2013a, b). At Daring Lake, the density declined 35% (10.73/1,000 km^2 to 3.72/1000 km^2, between 2004 and 2011) (Boulanger and Mulders 2013b). At Diavik, the density declined 34% (11.43 to 3.87/1,000 km^2, between 2005 and 2011), and at Ekati, the density declined 61% (10.05 to 6.14/1,000 km^2 over the same period) (Boulanger and Mulders 2013a). Wolverine densities were stable at

Kennady Lake between 2005 and 2006 where there were 4.6 to 5.2/1,000 km^2 (Boulanger and Mulders 2008). Wolverine declines were concurrent with declines in the Bathurst Caribou herd (Boulanger *et al.* 2011; Mulders pers. comm. 2013). These densities, even at their reduced levels, are in the range of moderate to high densities relative to other areas where Wolverines have been studied in North America (Table 2).

Coastal communities exported fewer Wolverine pelts than other communities, with Paulatuk exporting none from 87 carcasses, and Tuktoyuktuk exporting 6.6% from 136 carcasses between 2004/05 and 2011/12 (Branigan and Pongracz 2012; Rossouw unpubl. data 2012; data summarized in NWT SARC 2013). The Inuvik regional average pelt export rate was 19.2%. The carcass collections from other regions (Dehcho, Sahtu, South Slave and North Slave) rarely exceeded reported harvests annually between 2001/02 and 2011/12, and the total pelt exports exceeded the carcass collections over that period (Rossouw unpubl. data 2012; Mulders unpubl. data 2013). An unknown proportion of furs from these regions may be retained for personal use and do not enter the fur trade. Another source of unreported Wolverine harvest occurs in the Rennie Lake, NWT area by trappers from Saskatchewan (Mulders unpubl. data 2013). Between 2000/01 and 2008/09, an annual average of 38.7 pelts, representing 25.6% of the combined harvest, was recorded on export permits by Saskatchewan Conservation Officers.

The mean annual harvest over 20 years in the NWT is 109, and long-term harvest data are stable (Table 1, 2). The mean annual harvest estimate is approximately 200 Wolverines (Note: data corrected for furs not entering the fur trade in the Inuvik and other regions, and in the Saskatchewan/Alberta border region (NWT SARC 2013). The unreported harvest from other regions is difficult to estimate from available data and so was not used to augment the harvest estimate further. At the NWT population estimate of 5,100, the harvest rate is well below (< 3.9%) the intrinsic rate of growth of 6.4% per year in untrapped populations (sustainable if refugia and trapped areas are equal in size; Krebs *et al.* 2004). Cardinal (2004) identified several refugia from trapping in the NWT.

According to ATK holders, Wolverine population trends are variable across space and time but there is no clear indication of decline. From 2002-2004 studies, the majority of knowledge holders across the Northwest Territories reported Wolverine as stable or increasing (Autsÿl K'e Dene First Nation 2002; Nagy *et al.* 2002; WMAC and Aklavik HTC 2003; ABEKC 2004; Cardinal 2004), with the possibility of a decline near Yellowknife in 2004 (Cardinal 2004). In 2005, Inuvialuit hunters from Aklavik, Inuvik and Tuktoyaktuk indicated that Wolverines were more difficult to find (ICC *et al.* 2006), but in 2006-2007, Wolverine in Aklavik were said to be more abundant (ABEK 2007). More recent ATK is unavailable. There is evidence from harvest patterns and local knowledge that Wolverines are increasing in numbers on Victoria Island (Cardinal 2004; Banci *et al.* 2005), and Banks Island (Environment Canada 2013).

The Wolverine population of the NWT in 2003 was estimated at 3,500 to 4,000 residents, based on the range of statistical and non-statistical density estimates, and expert opinion, from other North American studies, and from a crude assessment of habitat quality (COSEWIC 2003; Slough 2007). More recent data on Wolverine densities suggests that an estimated 3,430-7,325 Wolverines may be present in the NWT (NWT SARC 2013). An additional 220-470 juveniles, many being transients, are estimated to be present in the fall (pre-trapping) population (based on an annual growth rate of 6.4%; Krebs *et al.* 2004).

Nunavut

The fur trade statistics for Nunavut are based on furs exported to fur auction (Table 1), which is an underestimate of total harvest (Cardinal 2004). Wolverine harvest has also been monitored with the Nunavut Wildlife Harvest Study (Nunavut Wildlife Management Board (NWMB) 2004).

Wolverine densities are moderate in the west and low on the arctic islands and the northeast and eastern mainland, where numbers are believed to be stable or increasing (Awan pers. comm. 2012). Between 2002-2004, Wolverine populations in the Kitikmeot region of Nunavut were reported to be fairly stable and robust with a slight cyclic pattern related to local food availability (Cardinal 2004; Banci *et al.* 2005); comparatively, this region also reported some of the highest levels of harvest in Canada (Cardinal 2004; NWMB 2004; ICC *et al.* 2006). Similar comments were provided for Herschel Island, the Yukon North Slope (WMAC and Aklavik HTC 2003), North Slave Region, NWT (Cardinal 2004; Henry 2004), the Kakinyne region (Autsÿl K'e Dene First Nation 2002) and around Old Crow, Yukon (Cardinal 2004; Henry 2004) during the same time period. Comments provided to the Canadian Wildlife Service during 2005 community meetings on the SARA listing of Wolverine and the Government of Nunavut management planning process described an increasing Wolverine population (Han pers. comm. 2012). Communities involved included Gjoa Haven (King William Island), Kugaaruk, Cambridge Bay (Victoria Island), Arviat and Rankin Inlet. Awan *et al.* (2012) reported opinions of 65 Nunavut hunters; 58% believed that the Wolverine population in their area was increasing, 40% believed that it was stable, and 2% believed it was decreasing.

Wolverine densities at High Lake (near Coronation Gulf) and Izok Lake (near the NWT border), were estimated at 6.85/1,000 km^2 and 4.80/1,000 km^2, respectively, in 2008 (Poole unpubl. data 2013). Both of these study areas were 3,000 km^2 and are in the Southern Arctic Ecozones.

The Nunavut Wildlife Harvest Study reported annual harvests from Nunavut communities in Wolverine range were < 5-20 Wolverines per year, except in Kugluktuk, where the harvest was estimated at 80-100 per year (NWMB 2004). In the Nunavut carcass collection program, the average annual reported harvest in Kugluktuk from 1986-2012 was 63 Wolverines. Wolverines were harvested (2009/10 to 2011/12) near most Nunavut communities including Coral Harbour (Southampton Island), Gjoa Haven, Cambridge Bay, and other locations on Victoria Island. No harvest was reported from Baffin Island, although Wolverine tracks were reported near Clyde River on northeastern Baffin Island in the winter of 2011/12 (Awan pers. comm. 2012). The only Wolverine harvest reported from the Qikiqtaaluk (Baffin) Region was from Hall Beach, Melville Peninsula, and Igloolik. The local overharvest of Wolverines may take place near communities and concentrations of Barren-ground and Dolphin and Union Caribou, depending on re-population from neighbouring refugia.

British Columbia

Lofroth and Krebs (2007) used a habitat quality rating system empirically derived from estimates of Wolverine density to predict Wolverine distribution and abundance at a provincial scale. Density and habitat association data were obtained from two study areas, the Columbia Mountains (7,000 km^2, 1994-2002) and Omineca Mountains (8,900 km^2, 1995-2001), where densities were estimated at 5.8 and 6.5/1000 km^2, respectively. Wolverine numbers for the province were estimated at 3,530 (95% C.I. 2,700–4,760) (Lofroth and Krebs 2007). The lack of density data for low and rare areas could introduce error in the overall estimate. Mean densities were estimated at 0.3/1,000 km^2 in rare-quality habitat, 4.1/1,000 km^2 in moderate-quality, and 6.2 Wolverines/1,000 km^2 in high-quality habitat. These estimates are consistent with 4.8/1,000 km^2 reported by Quick (1953) for moderate quality habitat in northeast BC. The Shuswap Indian Band noted a decrease in Wolverine abundance in the Secwepemc Traditional Territory, which they attributed to overhunting and loss of important migration routes (Shuswap Indian Band 2008).

The Vancouver Island population is believed to be very low, or extirpated. Unverified sightings are reported almost annually to the British Columbia Ministry of Environment (Lofroth pers. comm. 2012). The last confirmed record was in 1992 (BC Government 2013) and it is possible that they have been extirpated.

Alberta

A population estimate for Wolverine in Alberta is unavailable. It is likely that the population was low in the 1950s during rabies control programs when non-selective poisoning killed 5,500 Wolves and an unreported number of Wolverine (Petersen 1997). Wolf control using aerial shooting and poisoning is ongoing in the west-central Alberta range of the Little Smoky Boreal Caribou herd (Campbell 2012), where at least 650 Wolves have been killed since 2005. A quota of one Wolverine harvested per trapline has been in place since 1989.

Opinion surveys of trappers in Alberta suggested a stable population existed north of 56°N latitude but was declining elsewhere in 1987, and in 1994, there was a province-wide declining population (Petersen 1997). An analysis of Wolverine harvest data from 1985-2011 has shown that the number of traplines harvesting Wolverines, and the average Wolverine harvest by trapline have increased since the early 1990s (Webb *et al.* 2013). Harvests increased significantly in the Northwest Boreal and Foothills natural regions, but declined in the Canadian Shield and Rocky Mountains regions. It is not known whether the increased or decreased harvest is due to changes in Wolverine populations, trapper effort, or other factors.

During 2005-2008, Fisher *et al.* (2013) used genetic tagging to conclude Wolverine densities of 6.8/1,000 km^2 in the Willmore Wilderness Park, Rocky Mountains and 3/1,000 km^2 in a foothills study area near Hinton and Grande Cache. Based on camera trap data, Fisher and Heim (2012) believe that the pattern of abundance is similar farther south in the montane Banff National Park, as compared with Alberta's East Slopes. Northern boreal habitats have not been studied.

Saskatchewan

Harvests are low in the southern boreal forest (218,612 km^2) and higher in the north (132,958 km^2) (Siemens Worsley 2011), therefore Wolverine abundance is believed to follow the same pattern. The population is crudely estimated as <1,000, based on range and density assumptions. Trapper questionnaire responses from the South Saskatchewan Trapping Area and the Northern Fur Conservation Area reported that Wolverine were viewed as 'scarce' in both regions (2006/07 to 2011/12) (Gollop 2012).

Manitoba

Wolverines inhabit the northern part of the province, north of 53° latitude (Berezanski 2004). Highest densities appear to be in the northeast, but the northcentral and northwestern regions receive less trapping effort and may represent a population reservoir for surrounding regions. Wolverines were historically rare in southern Manitoba, where human developments forced the range limit north (Berezanski 2004).

Using harvest data, the Wolverine population in Manitoba was estimated at between 500 and 800 animals (Johnson 1990). Berezanski (2004) used a sustainable harvest rate of 6% (from Krebs *et al.* 2004), and the assumption that the harvest was sustainable in Manitoba, to estimate a population of 1100-1600, with 1100 more likely because of presumed lower productivity compared to other areas in western Canada (Berezanski 2004).

An increase in harvest in the 1980s was due to a number of factors, including the cessation of Wolf poisoning, an increase in carrion from Wolf kills, a trapping season closing date that offered some protection to females with kits (which may allow increased production), and an increase in fur prices and associated trapping activity (Johnson 1990). The Wolverine harvest rate since 1980 has been highly variable, but has not significantly changed (Berezanski pers. comm. 2013). The population is thought to be stable overall (Berezanski 2004) and based on harvest records, may be increasing in the Churchill area in the northeast and possibly the south (Berezanski pers. comm. 2013). Wolverine populations in northeastern Manitoba may be benefiting from the increase in the Pen Island (Eastern Migratory) Caribou herd, which is having the same beneficial effect in northwestern Ontario (Dawson 2000; Berezanski 2004). Keeyask Hydro Limited Partnership (2012) reported Wolverine populations to be increasing in the Keeyask region and lower Nelson River region of northern Manitoba, with increases first noted in 2009, albeit this evidence came from a single trapper.

Ontario

Some ATK indicates that Wolverines have always been rare, but have been consistently present with no discernible changes in relative abundance since the 1920s, yet others suggest increases since the late 1970s or early 1980s (Ray 2004). Wolverines reappeared in the Winisk-Peawanuck area in the mid-1990s (Dawson 2000).

Wolverine distribution in Ontario was summarized by the Ontario Wolverine Recovery Team (2013). Wolverines are currently found in northwestern Ontario following a range reduction in the 1800s due to habitat conversion during human settlement, logging and railroad construction, and the overharvest of ungulates (Ontario Wolverine Recovery Team 2013).

There is some evidence from aerial surveys and ATK that Wolverine have recently expanded their range east of the 'peripheral' range (Figure 4) following increases in the Pen Islands Caribou herd in the 1980s and 1990s (Dawson 2000), and changes in Boreal Caribou distribution in the Hudson Bay Lowland (Magoun *et al.* 2004, 2005a; Ray 2004). Ray (2012) recorded incidental Wolverine observations to < 200 km from the Québec border. A Wolverine was harvested in 2012 near the same limit (Dawson pers. comm. 2012). Kelsall (1981) believed that the Wolverines in Ontario were isolated from those in Québec and Labrador, but that may no longer be the case.

The population estimate for Wolverines in Ontario is 458 to 645 (Bowman pers. comm. 2013), based on an estimated minimum density of 1.4 Wolverines/1,000 km^2 in a 7,626 km^2 study area, where a DNA mark-capture study was undertaken (Dawson *et al.* unpubl. data). If Wolverines persist at similar densities across the province, the Ontario population estimate would be 645. However, results from aerial surveys (Ontario Wolverine Recovery Strategy) suggest that densities are not uniform and this estimate was assumed to be representative of the higher end of the spectrum in the province. Therefore, dividing Wolverine range into high (274,551 km^2) and low density (172,563

km^2) areas, and assuming the density in the latter are to be 0.7/1,000 km^2, yields an estimate of 458 Wolverines. There are no confidence limits on this estimate.

A zero quota was applied to non-aboriginal trappers in 2001/02 and the season was closed in 2009, but occasional accidental kills of 1 - 4 occur annually (Dawson pers. comm. 2002; Bowman et al. 2010). Treaties in northern Ontario allow for Aboriginal peoples to continue harvesting Wolverines for their own use (Heydon pers. comm. 2002).

Québec

The historical harvests of Wolverine in Québec are not well documented. Historical Hudson's Bay Company fur trade data from Fort Chimo (now Kuujjuak) from 1868 to 1923 documents a harvest of ≥1190 Wolverine pelts, with a sharp decline from 23 pelts/year, to 4 pelts/year in the 1914-1923 period (Schmelzer unpubl. data 2012). Harvests ranged between 0 and 24 per winter since Statistics Canada began keeping records in 1919 (Fortin *et al.* 2005). These data have led to the assumption that the species was never particularly abundant in the Eastern Population (Fortin *et al.* 2005). The harvest of Wolverines was banned in Québec in 1981, except in the James Bay and northern Québec Agreement area, which covers much of northern Québec. Current and past generations of Aboriginal knowledge holders from northern Québec report Wolverine as being very rare (COSEWIC 2012b).

Wolverines have not been confirmed to occur in Québec since the last specimen was captured in 1978. An individual captured in the Lanaudière region in 2004 was cited in Fortin *et al.* (2005) as evidence of remnant Wolverines but it has since been established that it had escaped from a zoo in Ontario (Ministère des Ressources naturelles et de la Faune du Québec 2013). There were about 60 unconfirmed reports from Québec and Labrador between 1965 and 2004 (Fortin *et al.* 2005). Over 70 observations were reported between 2000 and 2012 (Thibault unpubl. data 2013; Figure 5); 14 were considered 'probable', 35 'likely', and 22 'questionable', but none were verified. Unverified records based on tracks should be viewed with some skepticism because track size and shape varies with changing snow conditions (McKelvey *et al.* 2008).

Based on recent observations and research (see **Search Effort** section), Wolverines are either very rare, are at a level where they are not detectable using current survey effort, or are extirpated in Québec.

Labrador (mainland Newfoundland and Labrador)

A review of historical Wolverine fur trade data from Hudson's Bay Company posts in Davis Inlet and Moravian Missions of Hebron and Okak in Labrador indicated 873 Wolverine pelts were traded between 1844 and 1923 (Schmelzer unpubl. data 2012). Some pelts traded at Fort Chimo, Québec likely originated from Labrador (Moores pers. comm.). Wolverine pelts continued to be traded until the mid-1900s (Schmelzer 2006).

Over 40 unconfirmed sightings of Wolverines were reported over the last 30 years (Schmelzer 2012). The lack of verified records from numerous surveys (see **Search Effort** section) led to a conclusion that Wolverines may be extirpated from their range in Labrador, and that populations in neighbouring Québec are too low, or absent, to support recolonization (Schmelzer unpubl. data 2012). Innu elders report knowing little about Wolverine at present and suggest they are very rare (Paul F. Wilkinson and Associates Inc. 2009), although they were relatively abundant around 1935-1940 in the Schefferville area of Québec and Labrador (Clement 2009).

Canadian Population Estimate

The population is unknown, but likely > 10,000 adults. If harvest data are accurate, and if population size can be adequately extrapolated from density estimates, the Wolverine population estimates (mature individuals) would be as follows: Yukon (3,500 to 4,000), NWT (3,430-7,325), BC (2,700 to 4,760), Saskatchewan (<1,000) and Manitoba (1,100 to 1,600). The available information on distribution and known densities in similar ecological areas suggests that populations in the remaining jurisdictions are approximately as follows: Alberta, 1,500 to 2,000 (Wolverine range is relatively extensive, with some high quality habitats); and Nunavut, 2,000 to 2,500. The estimate for Ontario is 458 to 645 Wolverines. The result is a total Western sub-population estimate of 15,688 to 23,830 adults. However, these estimates assume trapping effort is constant and that Wolverine densities are relatively uniform across the range.

There is no estimate for the Eastern Wolverine sub-population and the last verified record was in 1978. The lack of verified records among the many reported observations (Figure 4) implies that the population is very small (<100 individuals), and possibly extirpated.

Fluctuations and Trends

Wolverine population fluctuations and trends were discussed by jurisdiction in the **Abundance** section. To summarize, population estimates are uncertain but there are likely >10,000 Wolverine in the population. Trend is unknown but information from harvest and trapper survey indices suggests sub-populations are increasing in parts of the NWT, Nunavut, northern Alberta, Manitoba, and Ontario, but decreasing in the southern range. Extirpations (or near extirpations) have occurred in a substantial portion of the historical range, including eastern Canada, the Prairies, and Vancouver Island. It is unknown if past declines in the Southern Mountains National Ecological Area of BC and Alberta have continued since the last assessment (COSEWIC 2003).

There is no evidence of population changes in the range of the eastern sub-population (Québec-Labrador).

A minimum of 559 Canadian Wolverine were killed in 2009-2010, and over the last 17 years (1992-1993 to 2009-2010, there have been similar harvest levels (range 385-637) across Canada (Table 1).

Rescue Effect

Nuclear DNA evidence of genetic similarities suggests connectivity currently exists between Alaska and western Canada (Gardner *et al.* 1986; Kyle and Strobeck 2001, 2002). Wolverine populations in Alaska are continuous with those in the Yukon and BC, making rescue along the international boundary with Alaska likely. Wolverine density estimates in Alaska are presented in Table 2.

The likelihood of rescue of Canadian Wolverine populations from the conterminous United States is negligible. Increasingly fragmented populations currently inhabit montane regions in Washington, Idaho, western Montana and Wyoming (Aubry *et al.* 2007; Figure 3). The total number of Wolverines inhabiting this area may be 35 (credible limits 28-52) (Schwartz *et al.* 2009). Genetic sub-structuring has been documented in Wolverine populations in Idaho (Kyle and Strobeck 2002) and Montana (Cegelski *et al.* 2003, 2006), suggesting relatively low migration rates between adjacent mountain ranges.

THREATS AND LIMITING FACTORS

An IUCN Threats Calculator was conducted among jurisdictions and COSEWIC members in order to document the scope and extent of major threats (Appendix 1). The overall Threat score was 'medium', due mainly to concerns with declining Caribou populations, response to disturbances such as road and infrastructure development, and access leading to potential unsustainable harvest levels.

Threats have been identified in several recent documents, including the 2003 COSEWIC Status Report (COSEWIC 2003), the Ontario Wolverine Recovery Plan (OWRT 2013), and the Eastern Population Recovery Plan (Fortin *et al.* 2005). Habitat loss, habitat fragmentation, and climate change continue to threaten Wolverine populations at the southern and eastern peripheries of their range. Habitat loss results from conversion of natural habitats for human land uses including agriculture, ranching, urban and suburban developments, mining, oil and gas development, hydroelectric reservoirs, and associated road networks that facilitate access for harvest and disturbance.

Threats to the eastern sub-population relate mainly to loss of carrion associated with declining Caribou herds, hydroelectric developments, and road density in areas with increased resource development. Threats in the southwestern range relate mainly to declining Caribou, roads, increased access and potential overharvest, and climate change. Threats in the northern range relate mainly to resource development sites, harvest, and declining Caribou in some areas. Details are discussed below.

Harvest

Harvest is presently the human activity with the greatest potential to directly reduce Wolverine populations to levels which could have a detrimental effect on metapopulation dynamics and cause extirpation (Lofroth and Ott 2007). In BC, the harvest of Wolverine was stable at the provincial level, but was unsustainable in 15 of 71 population units (Lofroth and Ott 2007). Low densities, large home range size, and long-distance movements by dispersing individuals contribute to the Wolverines' vulnerability to trapping and hunting. An increased vulnerability of Wolverines to trapping after Snowshoe Hare population crashes leads to the false perception that they are more abundant (Hatler 1989; Jung *et al.* 2005; Slough 2009). Banci (1987) noted an increase in the harvest of adult males in March 1983 following a Snowshoe Hare population crash.

Harvest levels have remained stable in western jurisdictions (Table 1). Harvest management, including trapping closures, limited seasons, quotas, limited entry, and registered trapping concessions have reduced these threats in most jurisdictions (Slough *et al.* 1987; Johnson 1990). Beneficiaries of the Nunavut Land Claims Agreement are not restricted to these harvest rules (although members may have local restrictions; Crystal pers comm. 2014) and harvest rates by beneficiaries are not as well documented. Exported Wolverine furs require permits but a high proportion of Wolverines from the Arctic are used locally and not exported to fur auctions, so there is a potential for overharvest going unnoticed. The estimated annual harvest of Wolverines (including unrecorded harvests from Yukon, NWT and Nunavut) is likely <1,000.

Survival was <0.75 among all age/sex classes in trapped areas, and >0.84 in areas where trapping does not occur (Krebs *et al.* 2004). Intrinsic rates of increase (λ) were estimated at 0.88 in trapped populations and 1.06 in untrapped populations. Survival was highest among adult females (0.88 in untrapped areas, 0.73 in trapped areas) and lowest among subadult males (0.45 in trapped areas) (Krebs *et al.* 2004). This evidence suggests that most trapped populations would decline without immigration from refugia. Local overharvest of Wolverines may occur in some areas (Krebs et al. 2004), but this harvest is largely replenished by immigrants from untrapped refugia. Cardinal (2004) identified several refugia from trapping across northern Canada. The consideration of use of untrapped areas as functional refugia in trapline management is a strategy practised by many trappers and promoted in trapline education (*e.g.,* Yukon Department of Renewable Resources, no date). Many refugia are de facto, where trapping areas are simply large and inaccessible. Krebs *et al.* (2004) pooled data from 12 North American studies, and estimated that at an average harvest rate of 12.2%, and an intrinsic rate of increase of 6.4%, refugia from trapping would need to cover twice as much area as harvested areas. Self-management by trappers and inaccessibility are the primary sources of refugia. The percentage of land not subject to harvest is unknown but expert opinion during the Threats Calculator exercise estimated that 70-100% of the range (in jurisdictions where trapping is allowed) would be exposed to potential harvest. It is noted that refugia are not regulated and the

reliance on refugia to maintain a sustainable harvest is at risk of failure if incentives for harvest increase and refugia become trapped.

Refugia can quickly become accessible; in northeastern BC, 279,595 km of forest was cleared for seismic lines between 1996-2008, which is approximately an extra 2.54 km/km^2 of access for trappers (Weir pers. comm. 2014). The use of snowmobiles to run down Wolverine, or to get close and shoot one, is common in some jurisdictions (*e.g.*, Yukon; Jung pers. comm.) and there is concern that harvest by snowmobile, rather than traditional set traps increases the range of harvest and minimizes actual trap refugia.

Roads and Transportation Corridors

The increased density of roads in logged areas and elsewhere may have a direct effect on Wolverine and their prey (*e.g.*, Caribou), through disturbance (Krebs *et al.* 2007; Bowman *et al.* 2010). Roads also place Wolverines vulnerable to trapping and road mortality. Gwich'in in the Mackenzie River region suspect the Mackenzie Valley Highway will increase access to harvest, and roadkill of Wolverine (GRRB 2014). May *et al.* (2006) found that Wolverines in Scandinavia selected home ranges based on degree of human development and, to a lesser extent, habitat quality, and in Ontario, road densities had an apparent influence on home range selection (Dawson *et al.* 2010). Areas with roads or human structures were avoided or selected less than large roadless areas. A similar relationship was found in the northwestern conterminous US where road density or human population density were more important than quantity or quality of vegetation in determining Wolverine counts (Rowland *et al.* 2003). Their watershed-scale models predicted lower Wolverine counts at higher road densities (road densities of 0.44 to 1.06 km/km^2). In the Rocky Mountain region, Carroll *et al.* (2001) predicted a decline in the occurrence of Wolverines when road densities exceeded approximately 1.7 km/km^2. The mean road density in Wolverine home ranges was 0.43 km/km^2 in Ontario, and individuals whose home ranges had a higher road density than the mean had a higher risk of mortality due to anthropogenic factors (Bowman *et al.* 2010). Wolverines were less abundant in areas with human activities including roads (mean road density of 0.37 km/km^2) and logging (*i.e.*, temporary and functional habitat losses) (Bowman *et al.* 2010). Resource development is often accompanied by road access, so road density serves as a proxy for the extent of the human footprint (Bowman *et al.* 2010). Road density is not only associated with avoidance behaviour by Wolverine, but there is an increased mortality risk due to trapping, hunting, and collisions with vehicles.

Large highways and other transportation corridors such as those in southern Alberta and BC may act as barriers to movements and dispersal, and may be a source of mortality (Gibeau and Heuer 1996). Disturbance by noise (Golder Associates 2003) and traffic may lead to avoidance of transportation corridors. Gibeau and Heuer (1996) documented two highway mortalities of Wolverine in Banff National Park, where they also noted patterns of approach and retreat behaviour before successfully crossing roads during busy periods. Austin (1998) found that Wolverines selected narrow crossings (*i.e.* <100 m wide), avoided areas within 100 m of the Trans-Canada

Highway, and preferred areas more than 1,100 m away. Alexander *et al.* (2005) studied the effect of traffic volume on the carnivore guild, which included Wolverines, in the same area. They suggest that a carnivore movement threshold exists between 300 and 500 vehicles per day, or an average annual daily traffic volume (AADT) of 3000-5000, assuming a 10:1 annual to winter traffic ratio. No wolverine crossings (n=39) were detected at that traffic volume (Alexander pers. comm. 2013). The AADT in Banff National Park is 14,000, and similar volumes are likely for the Trans-Canada highway westward through Wolverine range.

Wolverine gene flow and movements across highway crossing structures (underpasses/overpasses along fenced sections of highway) are being assessed on an additional 30 km of the Trans-Canada Highway (TCH) twinned in Banff National Park (Clevenger *et al.* 2011a). A larger study is monitoring the occurrence and rate of all wildlife-vehicle collisions and use of crossing structures (Clevenger *et al.* 2011b). In the 17 years (1996-2014) of monitoring of the TCH, there have been 10 recorded crossings (9 using underpasses, 1 using overpass) by at least two different Wolverines (Clevenger, 2013; Clevenger pers. comm. 2014). Genetic typing from hair samples indicates five males and two females crossed the TCH over a three-year period, though they were most likely crossing at unfenced sections. There have been four mortalities since 1980 at unfenced parts of the TCH. Sample size is low but early results suggest that the TCH is not a barrier to males, and may be for females (Clevenger pers. comm. 2014).

Biological Factors

Biological factors that limit Wolverine populations include the species' low intrinsic rate of increase, low natural densities and large home ranges (Banci and Proulx 1999). Conversely, long-distance dispersal abilities give Wolverines the capacity to recolonize vacant habitats (Vangen *et al.* 2001; Flagstad *et al.* 2004). Re-population may take several decades but is possible where factors favour Wolverine survival (Johnson 1990; Vangen *et al.* 2001).

Indirect effects on the prey base and large carnivores, which impact scavenging opportunities, will also impact Wolverine populations. Such effects include overhunting of ungulates and carnivores, and population declines of prey and carrion due to loss and fragmentation of their habitats (Cardinal 2004). A recent recolonization of southern Scandinavia by Wolves led to an increase in scavenged Moose in the diet of Wolverine, and a decrease in the occurrence of Wolverine-killed Caribou and rodents (van Dijk *et al.* 2008).

The availability of prey and carrion is another biological limiting factor (see **Habitat Requirements** section). Wolverines rarely prey on livestock in North America (as they do in Europe; Landa *et al.* 1997) and so are not directly targeted for predator control. Wolf poisoning programs in western Canada that killed Wolverines as by-catch ended in the 1970s, but were reinstated in west-central Alberta by 2005. Wolverines may be impacted by Wolf reduction programs designed to reduce predation on declining Boreal Caribou herds.

Climate Change

Spring snow cover during the denning period is an important habitat requirement of Wolverines (Aubry *et al.* 2007; see **Habitat** section). Climate models predict increases in temperature and precipitation in Canada (IPCC 2007), with the largest warming projected for northern Canada. Precipitation is likely to increase in winter and spring, but decrease in summer. Snow season length is predicted to decrease, but a net increase in snowfall should make up for the shorter snow season, resulting in a net increase in snow accumulation. Spring snow cover in the Arctic has melted about 4-7 days earlier since the late 1980s (Foster *et al.* 2008), and earlier snowmelt is also occurring in the western mountains (Stewart 2009).

The impact of reduction of snow on Wolverine is uncertain (Wolverine Science Panel 2014). In northern range, earlier snowmelt may not be an issue because snow persists during the natal denning period (Magoun and Copeland 1998). However, in mountainous regions, particularly in BC and Alberta, decreasing spring snow is considered a serious threat. Productivity could decrease, range could shift and habitats and populations could become more fragmented (Copeland *et al.* 2010; McKelvey *et al.* 2011; Weir pers. comm. 2013).

Public Attitude

Societal views on Wolverine vary from dislike due to the damage they cause to traps, animals, cabins, and food caches, to respect for their abilities (see **Special Significance** section). Attitudes could be an impediment to recovery of Wolverine population in Québec and Labrador where even low mortality levels would significantly impact the population (Fortin *et al.* 2005).

Recreational Activities

Wolverines prefer large roadless areas, but home ranges frequently overlap active traplines, cross-country ski trails, busy roads such as logging roads, seismic lines (Krebs *et al.* 2007), and the edges of communities. Winter recreation in the form of helicopter skiing and backcountry skiing, snowmobiling (*e.g.*, nigh-marking) and the presence of roads reduced habitat values (*i.e.*, functional losses) for Wolverines in the Columbia Mountains, BC (Krebs *et al.* 2007).

Habitat avoidance results from human activities such as backcountry recreation, which may impact Wolverine behaviour patterns such as denning, kit rearing, travel and foraging. Disturbance of Wolverine maternal den sites may lead to den relocation or litter abandonment (Myrberget 1968; Pulliainen 1968). Evidence for direct impacts of winter recreation on denning Wolverines is conflicting (Copeland 2009; Heinemeyer and Squires 2012), but helicopter skiing and backcountry skiing in western Canada have been shown to reduce functional habitat values for Wolverines, especially adult females (Copeland *et al.* 2007; Krebs *et al.* 2007; May *et al.* 2012), whose reproductive success may be affected (Carroll *et al.* 2001; Rowland *et al.* 2003; Copeland *et al.* 2007; Krebs *et al.* 2007; Copeland 2009). Aboriginal knowledge holders feel that the use of snow machines has changed harvesting practices and patterns, allowing people to travel further and faster, which has resulted in increased Wolverine harvest (WMAC and Aklavik HTC 2003; Cardinal 2004; Banci *et al.* 2005). Wolverines opportunistically use inactive snowmobile trails for travel and scavenging trapped animals and hunter kills.

Conflicts at Resource Development Sites

Wolverine-human conflicts at mining camps have recently been identified as an potential threat to Wolverine populations in the NWT and Nunavut, where diamond mines in particular are becoming more common in the Southern Arctic ecozone. Wolverines generally avoid areas of human activity but are curious, and will investigate campsites, food caches, garbage dumps, cabins, traplines, and hunter kills, usually when humans are not present, and scavenge for food. Occupied mining camps are approached in the NWT and Nunavut for food and shelter.

Wolverines usually maintain a separation distance of at least 500 m from human activity (AXYS 1998), but attraction to food sources at camps and other areas of human activity (see **Physiology and Adaptability** section) may result in the habituation of animals, and increased vulnerability to problem wildlife control, hunting and trapping, and collisions with vehicles (NSMA 1999; Golder Associates 2003). Adaptive mitigative measures are used to reduce Wolverine occurrences at diamond mines (Golder Associates 2012a, b; Rescan 2012). There were one nuisance-control mortality and four relocations at the Ekati diamond mine between 2003-2011 (Rescan 2012) and one accidental human-related Wolverine mortality at Snap Lake in 2011 (Golder Associates 2012a). There were two incidents of Wolverines being deterred from the camp prior to 2008, and 8 cases in 2008 (Golder Associates 2010). There were 47 incidents involving Wolverine deterrence from 2000 to 2011 at Diavik mine. There were also two relocations and two mortalities (DDMI 2012). There were 30 incidents involving Wolverine deterrence and two reported mortalities at Meadowbank gold mine in the Kivalliq region, Nunavut, in 2011 and 2012 (Lecomte pers. comm. 2013). ConocoPhillips (2006) waste management plan recognizes that certain petroleum-based products such as lubricants may attract Wolverine. Wolverine mortalities and relocations as a result of diamond mining activities appear minor, but in conjunction with trapping and hunting, may be contributing to local population declines (Boulanger and Mulders 2013a).

Responses of Wolverines to flying aircraft are variable, ranging from no response to running away and hiding (AXYS 1998). Generally, Wolverines are reluctant to abandon carrion, even when disturbed. A lack of response was most common (38 of 40 encounters) in fly-overs in the Yukon (Jung pers. comm. 2013).

Number of Locations

The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all Wolverines present. As such, there are 'many' locations in Canada.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, Wolverines are harvested in all northern and western jurisdictions (Manitoba, Saskatchewan, Alberta, BC, Yukon, NWT, and Nunavut). There is no non-aboriginal harvest permitted in Québec, Labrador or Ontario (since 2001/02). Aboriginal harvest is permitted in the northern part of the range in Québec, as per the James Bay and Northern Québec Agreement: Fortin *et al.* 2005). The incidental harvest of Wolverine still occurs in Ontario (Ontario Wolverine Recovery Team 2013). In the United States, Wolverine harvest is permitted in Alaska and Montana, although it has been temporarily closed since November 2012 in Montana.

Harvests are managed with spatial and temporal restrictions including variations in season length, quotas, limited entry (*e.g.,* the use of registered trapping concessions, group and community trapping areas), and trapline management by the trapper (Slough *et al.* 1987). Harvests are monitored either through mandatory pelt sealing, year-end harvest reporting, or by monitoring fur exports. Local use of Wolverine pelts is common, particularly in Inuvialuit and Inuit communities in the NWT and Nunavut, where harvests are monitored using carcass collection programs (see **Sampling Effort and Methods** section).

Wolverines are not listed by the Convention on International Trade in Endangered Species; international trade in Wolverines is not monitored or restricted.

Non-Legal Status and Ranks

Wolverines were ranked Least Concern by IUCN in 2009 (IUCN 2012) due to their wide distribution and remaining large populations. Although there is an overall continued decline due to human persecution and land-use change, it is not at a rate sufficient to qualify for listing at this time. Previous listings by IUCN were Near Threatened (2008) and Vulnerable (1996).

The provincial/territorial status rankings for Wolverines are given in Table 3. Most rankings are similar to the COSEWIC (COSEWIC 2003) rankings for the Eastern and Western populations (Endangered and Special Concern, respectively). Provincial/territorial rankings are Endangered or Threatened for the Eastern Population, and Sensitive or Special Concern for the Western Population, although Wolverines are ranked Threatened in Ontario.

Table 3. Wolverine Status Ranks, Canada and U.S.A. Compiled July 2013.

Jurisdiction	COSEWIC / SARA	General Status[1]	Provincial/ Territorial	NatureServe[2]
Global IUCN: Least Concern				G4
U.S.A				N4
WA				S1
CA				S1
CO				S1
Idaho				S2
WY				S2
OR				S2
MT				S3
AK				S4
Canada		3		N3N4
NL	Endangered; Schedule 1	1	Endangered	S1
QC	Endangered; Schedule 1	1	Threatened	S1
ON	Special Concern; No Status	1	Threatened	S2S3
MB	Special Concern; No Status	3	Special Concern	S3S4
SK	Special Concern; No Status	1	No Provincial Ranking	S3S4
AB	Special Concern; No Status	2	Data Deficient	S3
BC (*luscus* ssp.)	Special Concern; No Status	3	Blue (Special Concern)	S3
BC (*vancouverensis* ssp.)	Special Concern; No Status	No Status	Red (Extirpated, Endangered, or Threatened)	G4T1QSH
YT	Special Concern; No Status	3	No Territorial Ranking	S3
NT	Special Concern; No Status	3	No Territorial Ranking	S3
NU	Special Concern; No Status	4	Sensitive	SNR

1. General Status Ranks: 0.1 Extirpated, 1 At Risk, 2 May Be at Risk, 3 Sensitive, 4 Secure (CESCC 2011).
2. NatureServe Status Ranks: G=Global, N=national, S=Subnational, T=Infraspecific taxon; H=Presumed Extirpated, 1=Critically Imperilled, 2=Imperilled, 3=Vulnerable, 4=Apparently Secure, 5=Secure, NR=Not Ranked, Q=Questionable Taxonomy (NatureServe 2013).

General status ranks (Canadian Endangered Species Conservation Council (CESSC) 2011) (Table 3) are Secure (NU), Sensitive (Canada, YT, NT, BC, MB), May Be at Risk (AB) and At Risk (SK, ON, QC, NL).

State listings for Wolverines are: Washington (Protected Wildlife; candidate), Idaho (Protected Nongame Species), Wyoming (Vulnerable), and Montana (Candidate). There is no state listing for Alaska. NatureServe ranks are provided in Table 3.

The U.S. Fish and Wildlife Service (2013) has proposed listing Wolverines in the conterminous United States as Threatened under the *Endangered Species Act*. The effect of climate warming on the snow pack is listed as the major threat, while backcountry recreation, timber harvesting and infrastructure development are not considered significant threats and therefore will be allowed to continue.

Habitat Protection or Ownership

Most of the Wolverine's range is on federal land administered by Aboriginal Affairs and Northern Development Canada. Modern land claim and self-government programs have resulted in the ownership of settlement lands by Aboriginal governments and authorities in Yukon, NWT, Nunavut, and BC. Land use activities on both Aboriginal and non-aboriginal lands, not defined as settlement lands, are administered by the applicable land manager in consultation with First Nations, Inuvialuit, and Inuit.

Six communities in the Inuvialuit Settlement Region (Aklavik, Ulukhaktok, Inuvik, Paulatuk, Sachs Harbour, Tuktoyaktuk) have adopted community conservation plans, updated in 2008 (Joint Secretariat). Recommended Wolverine conservation measures include the identification and protection of important habitats from disruptive land uses, avoidance of den disturbance, discouraging hunting in summer, and forbidding the use of poison. Some conservation plans specify winter Wolverine harvesting areas.

Department of National Defence establishments in some parts of the country are used by Wolverine, including NWS radar sites in the Arctic (Shingle Point, Yukon; Horton River, NWT; Hall Beach, Nunavut), and properties in the Chilcotin (west of Williams Lake, BC) and Pierce Creek (south of Chilliwack, BC) (Nernberg pers. comm. 2012). Wolverines are suspected to be present at CFB Cold Lake, Alberta.

Kelsall (1981) and Dauphiné (1989) considered parks to be refugia from trapping and resource developments but some caution seems necessary in parts of the range because Wolverine trapping is permitted in most northern National and Provincial Parks of the western range. Also, Wolverines have large spatial requirements (see **Habitat** section) and sub-populations within the parks are not buffered from trapping activities around their peripheries. Wolverines that reside partly in refugia are susceptible to harvest mortality. Recreational activities, like snowmobiling and skiing, during the late winter denning period may result in disturbance to females and their litters, leading to relocation or abandonment (Heinemeyer and Squires 2012). The size requirement for an effective refugium from development has not been determined, but refugia larger than 20,000 km^2 may be required for an isolated habitat to maintain a viable population (Magoun *et al.* 2005b).

Trapping is permitted in many of the BC provincial parks, and by First Nations, Inuvialuit and Inuit Beneficiaries in national parks in Yukon, NWT, and Nunavut Territory, and in Wood Buffalo (NWT and Alberta) and Wapusk (Manitoba) National Parks. Most types of resource extraction or activities contributing to habitat losses and fragmentation are not permitted in protected areas. However, recreational activities, such as snowmobiling and skiing, which may disturb denning Wolverines, are generally not restricted and transportation corridors bisect and penetrate parks.

In Ontario, the habitat of Wolverine is protected from damage and destruction under the *Endangered Species Act*, 2007, and forest management operations are modified to maintain buffers around known Wolverine dens (OMNR 2010).

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Brian G. Slough obtained an M.Sc. from Simon Fraser University in 1976. His thesis on Beaver ecology led him to a 15-year career as furbearer management biologist with the Yukon Fish and Wildlife Branch. He has published work on furbearer species including Beaver, Arctic Fox, American Marten, and Canada Lynx, and has also written about trapline and furbearer management in northern and western Canada. He prepared COSEWIC status reports on Wolverine (2003), American Marten, Newfoundland population (2007), and Western Toad (2012). Mr. Slough has recently prepared NWT Species at Risk Committee status reports on the Northern Leopard Frog, Western Toad, and Wolverine.

Since leaving the Yukon government in 1996, Mr. Slough has conducted environmental assessments, protected areas research, and research on rare amphibians and mammals, including rodents, shrews and bats. He served two terms as a member of the Terrestrial Mammals Specialist Subcommittee of COSEWIC (2006 to 2013).

COLLECTIONS EXAMINED

No collections were examined during the preparation of this report.

Appendix 1. Threats calculator summary for Wolverine.

Species or Ecosystem Scientific Name	Wolverine (*Gulo gulo*)
Date	16/01/2014
Assessor(s):	Brian Slough (report writer), Graham Forbes (TM SSC Co-chair), Dave Fraser (BC), Gord Court (AB), Suzanne Carrière (NT), Shelly Moores (NL), Vivian Brownell (ON), Isabelle Gauthier (QC), Thomas Jung (YK), Ruben Boles (CWS), Patrick Nantel (Parks), Donna Hurlburt (ATK Co-chair) Jeff Bowman (TM SSC member); Nicolas Lecomte (TM SSC member), Neil Dawson (ON), Dean Berezanski (MB), Robert Mulders (NT), Janet Winbourne (TK Researcher), Emily Herdman (NL), Malik Awan (NU), Isabelle Thibault (QC), Vincent Carignan (CWS-QC), Victoria Snable (CWS-Prairie), Paul MacDonald (CWS-NL), Donna Begelow (CWS-NT), Rich Weir (BC)
References:	2014 Draft COSEWIC status report

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	4	4
Calculated Overall Threat Impact:		Medium	Medium

Overall Threat Comments	Generation time at least 5 years; hence severity assessed for 15 years.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential and commercial development		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
1.1	Housing and urban areas		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
1.2	Commercial and industrial areas		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
1.3	Tourism and recreation areas		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2	Agriculture and aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.1	Annual and perennial non-timber crops		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.2	Wood and pulp plantations		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs)	
2.3	Livestock farming and ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
3	Energy production and mining		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
3.1	Oil and gas drilling		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Increased access may lead to disturbance and mortality from road kill, trapping and nuisance control mortality at camps. BC: increase in access will increase harvest/trapping (see 5.1) Note: road networks are excluded in this calculation (see 4.1)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.2	Mining and quarrying		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Increased access may lead to disturbance and mortality from road kill, trapping and nuisance control mortality at camps. BC: increase in access will increase harvest (see 5.1) NT: There are 4 mines in NT that increase the disturbance and increase a number of related issues (see 5.1) Note: road networks are excluded in this calculation (see 4.1)
3.3	Renewable energy		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
4	Transportation and service corridors	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	(This would include habitat that are rendered ineffective from (ex.) mines and would include road kills as well)
4.1	Roads and railroads	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Transportation corridors may act as barriers to movements and dispersal, and may be a source of mortality (based on road mortality and the effects of access roads. This does not deal with active trapping but creating movement and avoidance) Scope BC: half the population would encounter roads YK: 30-70% of the population would encounter roads NT: the avoidance of roads is low but increase in access will increase hunting; believes that 11-30% of the Canadian population would experience roads Severity YK: there has only been 1 road kill in the past 10 years ON: 6-7 road kills documented BC: there have been a number of documented cases along TransCanada highway; mortality from road evident. There are also about 6-7 deaths associated with logging roads and highways in the southern portion of the range.
4.2	Utility and service lines		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Transportation corridors may act as barriers to movements and dispersal, and may be a source of mortality
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting and collecting terrestrial animals	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Wolverine harvest is restricted and monitoring is mandatory in most jurisdictions. Monitoring in NT and NU is by fur exports and voluntary carcass collection programs. The efficacy of harvest monitoring using carcass collections, in Inuit communities where most pelts are used locally, is uncertain. Harvest of ungulates and large carnivores may impact Wolverine prey and scavenging opportunities. Discussion: what % of Canadian pop. are exposed to trapping/hunting/bycatch? The only area that is excluded is where animals aren't accessible. Is untrappable area more than 30% in Canada? YK: most animals are exposed to hunting and trapping in YK. Even most parks north of 60° allow trapping (there are no legal barriers) ON: high but not large NL: none in NL NU: NU has more than 90% of the population and gov't has no jurisdictions BC: increase in road access (due to oil/gas/mining) will increase harvest Severity of the impact QC: Eastern situation is very different than elsewhere. Any mortality will have a high impact on the population to the east. MB: Wolverines are only hunted/trapped for a certain part of the year. Wolverine numbers are increasing in the province AB: has no information ON: 4-5 trapping this year. Similar to MB, Wolverine numbers are expanding in the province (eastward) YK: does not believe there is a decline in Wolverine numbers NU: same, range is also expanding eastward and towards the southern portion NT: agrees that severity is 1-10%; they are taking upwards of 200 and there is a slight range expansion up north BC: harvest is stable and range does not look like it is contracting The situation is more dire in the east but probably negligible for the whole country.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging and wood harvesting	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Road density in logged areas leads to disturbance and mortality from trapping and road kill. Ecological changes due to logging are not permanent, and not necessarily negative Scope BC: all of BC has logging; about 80% of the range QC: we need to look at the connectivity b/w QC and ON ON: most of the logging is in the southern end and the Wolverine population is located north of that. The effect is relatively small; about 1-10% in ON YK: fuel wood harvesting is higher here NT: logging is small but more than people might think. A plan in NT is a move towards oil harvesting. Comfortable with 1% for Canada's range Severity - question "if there is more logging, then wouldn't that mean better habitat for moose = better for Wolverine?" ON: around Red Lake it really depends on the forest. If forest is deciduous, then there is an avoidance by Wolverine, even though there are more moose Concern is that we cannot include cumulative effects of logging, which will change the hunting and trapping of Wolverines. That must be taken into account in 5.1
6	Human intrusions and disturbance	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Disturbance of denning females may lead to litter abandonment and kit mortality Discussion that 6.1 and 6.3 should be similar - difficult to separate recreational activity and other activities.
6.2	War, civil unrest and military exercises		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
6.3	Work and other activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Discussion that 6.1 and 6.3 should be similar - difficult to separate recreational activity and other activities.
7	Natural system modifications	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
7.1	Fire and fire suppression		Not a Threat	Restricted - Small (1-30%)	Neutral or Potential Benefit	High (Continuing)	Fires are a natural occurrence in boreal forests and ecosystem effects are positive for Wolverine. Forest fires definitely play a factor in the Western Boreal; scope is larger than 10%.
7.2	Dams and water management/use		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	Discussion on the declining caribou population * BC: there is a decline in the Southern Mountain pop. but the effec. is not a large factor; Wolverines have other ungulates to choose from (ex. moose) * YK: similar situation as BC; there is more diversity and Wolverines rely on more than just caribou * MB: unsure, but one staff certainly thought that moose could play a factor. It has been over 25 years since the big forest fire and there is an increase in moose habitat now; particularly in the northern part of MB. NT: Bathurst has a decline of 90% in herd size and about 70% decline in the central herd
8	Invasive and other problematic species and genes		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
8.1	Invasive non-native/alien species						MB: getting an increase in White-tailed Deer; another potential prey that could affect the Wolverine population Noted that forest pests are deall with under ecosystem change (7.3)
9	Pollution		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs)	
9.2	Industrial and military effluents		Not Calculated (outside assessment timeframe)	Unknown	Unknown	Insignificant/Negligible (Past or no direct effect)	This could be an issue, but not enough information exists YK: there was a paper done but cannot recall the findings

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural and forestry effluents		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
9.4	Garbage and solid waste						May result in habituation of Wolverine and resultant nuisance control mortality. Of the lone Wolverine found, garbage did not contribute to the death, it was a capture attempt and therefore would fall under hunting and trapping (5.1)
9.5	Air-borne pollutants		Unknown	Unknown	Unknown	High (Continuing)	
9.6	Excess energy		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	BC: there could be threats around oil/gas exploration or maintenance
10	Geological events		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	Moderate (Possibly in the short term, < 10 yrs)	
10.3	Avalanches/landslides		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	Moderate (Possibly in the short term, < 10 yrs)	Minor source of mortality Mortality of Wolverine might be insignificant, but the carrion and debris from avalanches might provide scavenging opportunities and den sites.
11	Climate change and severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting and alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Reductions in the extent of Wolverine habitat due to reductions in spring cover is disputable. It is likely that a decrease in snow season length would not impact natal denning requirements, because a net increase in snowfall should make up for the shorter snow season, resulting in increased snow accumulation. Any impact on Canadian Wolverine populations should be first detected in the Southern Mountain ecological area of BC and Alberta. A shorter snow season may increase primary productivity to the benefit of Wolverine. Discussion on snow conditions (US study) and if it'll happen in 10 yrs BC: the model forecast is within 25 yrs; more of a longer term issue. However, in the last 10 yrs, southern portion of BC had noticeable snow shrinkage NT: impact of snow is minimal in northern latitude. What would be the bigger issue is how climate change affects larger ungulates, thus having an effect on the scavenger species. Both a direct and indirect effect. YK: Unknown, but reduced snow length season would benefit Wolverines. The whole issue of the US study is controversial but most like the model that US has proposed. Expecting that the suitable snow conditions will shrink substantially over the long term; this will have an effect, but not sure by how much.
11.3	Temperature extremes		Unknown	Unknown	Unknown	Unknown	